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SEISMIC ENGINEERING DATA REPORT

STRONG-MOTION EARTHQUAKE ACCELEROGRAMS: DIGITIZATION AND ANALYSIS RECORDS FROM LIMA, PERU: 1951 TO 1974

OPEN-FILE REPORT 77-587

Prepared on behalf of the
National Science Foundation

Grant CA-114

This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards and nomenclature

Menlo Park, California

April 1977

U.S. GEOLOGICAL SURVEY, [Report-Open file series]

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RECORDS FROM LIMA, PERU: 1951 TO 1974

by

A. G. Brady and V. Perez

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PREFACE

This is the second of a series of reports planned to include the results of digitization and routine analyses of strong-motion earthquake accelerograms published by the U.S. Geological Survey. Serving as a model for this effort is the collection of data reports published by the Earthquake Engineering Research Laboratory of the California Institute of Technology during the years 1969 - 1975 and covering the significant records of the period from 1933 up to the San Fernando earthquake of February 9, 1971. The first of the present series of reports, Open File Report No. 76-609, covered the significant records of 1971 subsequent to the San Fernando earthquake. The present report includes the results of some ongoing work on Peru records.

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INTRODUCTION TO THE DATA MANAGEMENT PROJECT

A five year project for the continued operation and development of the national program in strong-motion instrumentation and data management was initiated in 1974 through an inter-agency agreement between the National Science Foundation and the U.S. Geological Survey. The present operation has overall direction and funding provided by the National Science Foundation while day-to-day management is provided by the U.S. Geological Survey.

Data Management is concerned with archiving the original records, processing the significant records, and disseminating the resulting data and other information to the user community. One objective of data management is to develop a complete and unified processing system for the strong-motion data recorded by the networks of instruments. This report contains the results of processing the following ten records obtained from Lima, Peru during the period from 1951 to 1974:

1. Geological Institute, Plaza Habich, January 31, 1951
2. Instituto Geofisico del Peru, Avenida Araquipa, October 17, 1966
3. Instituto Geofisico del Peru, Avenida Araquipa, May 31, 1970
4. Instituto Geofisico del Peru, Avenida Araquipa, November 29, 1971
5. Instituto Geofisico del Peru, Avenida Araquipa, January 5, 1974
6. Zarate Station, January 5, 1974
7. Instituto Geofisico del Peru, Avenida Araquipa, October 3, 1974
8. Las Gardenias, Huaco Residence, October 3, 1974
9. Instituto Geofisico del Peru, Avenida Araquipa, November 9, 1974
10. La Molina Station, November 9, 1974

DATA PREPARATION AND DIGITIZING

The criteria and procedures used in the strong-motion data management project for the selection, preparation and digitization of records is as follows.

Significant records. An arbitrarily selected peak amplitude of 5% g has been chosen as the main criterion for a record to be considered significant, if it is a ground level record, and 10% g if an upper story structural record. This may be altered for future reports if the number of records designated "significant" by the 5% criterion becomes greater (or less) than the current staff and program can expeditiously handle.

Film preparation. One aspect of the archiving system for the significant records is the preparation of full-size contact film negatives from the original records which were recorded in the field on photographic paper or film. This reproduction process is carried out under the supervision of the staff of the Seismic Engineering Branch by commercial photographic concerns in the San Francisco Bay Area, using the original records. From these film negatives, contact prints are made on Mylar-based film, either translucent frosted film for subsequent hand digitizing, (e.g., 6 in. or 12 in. records), or clear film for automatic digitizing procedures (e.g., 70 mm records). Measurements have shown that these prints differ in size from the original film or paper records by less than 0.1%. The Mylar film is mechanically strong, dimensionally stable, and affords excellent optical contrast. Experiments on photographic development techniques have resulted in standard methods for producing an optimum balance between contrast and trace width.

For 6 in. and 12 in. photographic paper records a choice is made, depending on the convenience of the digitizer, whether to digitize from the original or a contact print. For 70 mm or 35 mm film records, digitizing by hand requires enlargement of the original. The enlargement is 2X or 3X for 70 mm film, and 3X for 35 mm film, these being a compromise between the resultant effective sensitivity of the acceleration traces, the original length, and the size of the vacuum table carrying the copying film. Without compromise is the requirement that the enlargement be performed in one step, using a lens of absolute minimum distortion, and viewing the entire original length in one frame.

Digitizing options. The 12 in. records in this report have been digitized at Dynamics Graphics, in Berkeley, California, on a Calma digitizing system. This includes a hand-held restrained cursor moving on a 60"-long table with resolution of 1000 points per inch and an RMS error of perhaps 0.003". Digitized output, selected at approximately 50 points per second of record time, is recorded on magnetic tape compatible with the U.C. Berkeley 6600 computer.

For 70 mm film, another digitizing facility is currently used. The I/O Metrics Corporation in Sunnyvale, California has a trace-following, laser scanning system, capable of handling a record in 12 cm sections, with a resolution of 1 micron (10^{-6} meter) and an RMS error of the order of 10 micron. Digitized output at approximately 500 points per cm (corresponding to 500 points per sec) is recorded on computer compatible magnetic tape. The 500 points per cm was chosen to lessen the chance that peak values would be seriously decreased in the digitization.

STANDARD DATA PROCESSING FOR ACCELEROGRAMS

Many slight variations in standard processing continue to be made as more experience is gained. A description of standard data processing as it currently exists follows.

All processing of the raw digital tapes is done at the U.C. Berkeley computer center and Lawrence Berkeley Laboratory facilities. The programs developed at Caltech during the years 1968 to 1972 (Trifunac and Lee, 1973), form the basis for the processing described here, but changes have been made as the procedures were upgraded and obvious changes were made in preparing the programs for use with the CDC 6000 and 7000 computer systems. The total programming package includes the following phases:

Phase 1: processing to obtain "uncorrected" acceleration data.

Phase 2: introduction of instrument correction and baseline correction to obtain corrected acceleration, velocity, and displacement.

Phase 3: calculation of response spectra and Fourier amplitude spectra at the same values of period.

Phase 4: note that the results of the fast Fourier spectra have not been adapted for inclusion in this report.

Phase 5: calculation of time-dependent spectra

Phase 1 - Uncorrected Accelerations. This first phase of processing presents the digitized accelerograms of strong earthquake ground motions as processed from records obtained from the strong-motion accelerograph network maintained by the U.S. Geological Survey. No base-line or instrumental corrections or adjustments have been made at this stage - the data may thus be regarded as "uncorrected" in the sense that no modifications have been introduced which involve any hypotheses as to the character of the ground motions or instruments involved. This digitized data is thus believed to be as close a representation of the original, raw information as it is feasible to achieve with digital processing.

The records have been digitized on an unequal time basis, which gives, if the points are well chosen, a good definition of the trace for a given number of data points. All visible local peaks and changes of slope have been picked, along with as many intermediate points as are needed to maintain an average number of points per second of record of at least 50 throughout the accelerograms. If equispaced data is needed for a particular computer program, it is a relatively simple matter to set up an interpolation program as the first step in the computation.

Considerable thought has been given to the length of record to be digitized. Although the actual strong-motion portion of the record is the most important part for engineering purposes, a sufficient length of the later lower amplitude accelerations have been included to permit studies of long-period characteristics. Such studies are, of course, limited by other factors of instrument characteristics and accuracy. For certain investigations for which the longer-period components are not important, only a fraction of the whole digitized record might be used.

Most records contain several traces produced by "fixed" mirrors rigidly attached to the accelerograph frame. In some cases, these fixed traces depart measurably from straight lines, usually involving long-period components to be ascribed to paper distortion, motions of the paper in the drive mechanism, etc. For all records on which fixed traces are present, the fixed traces are digitized at intervals of the order of one half-second, smoothed by weighted averaging over every three consecutive points, and subtracted from the accelerometer traces as a first step in the data processing.

Timing marks on the record were also digitized and smoothed by a 1/4, 1/2, 1/4 running average to form the basic time coordinate.

To fix the particular values of the digitized ordinates, some more-or-less arbitrary decision has been made as to the position of a straight reference line. When the record is placed on the table of the digitizing machine, it is lined up with the horizontal axis of the machine as closely as can be judged by eye. For this purpose the fixed traces serve as useful guides, as do the zero trace sections at the beginning of the record before the triggering of the instrument. It must be realized, however, that imperceptible shifts of the horizontal axis in translation or rotation lead to large deviations in double integrated displacement curves, so some technique which assures a uniform result is needed. For this purpose, the following procedures have been adopted. The film record is first placed on the digitizing table with the horizontal axis lined up by eye parallel to an estimated zero axis. If the record trace and the fixed mirror traces have been digitized without moving the record on the table of the digitizing machine, then the subtraction of the two traces will correct for any slight rotation of the record on the table, so that only translation of the horizontal axis is required. This axis is therefore translated to a position which reduces the integral of the digitized acceleration curve to zero, when the integral is taken over the length of the record. This is, in principle, the same as making the mean acceleration value zero, or making the sum of the squares of the deviations from the horizontal axis a minimum. Although this means physically that the change in ground velocity from beginning to end of the record is zero, which is actually not the case for records triggered by the excitation itself, this method for selecting the horizontal axis position would seem to be the most logical choice for a standard procedure.

For those few records for which fixed traces are not available, or for which the record has been moved on the table between the digitizing of the record trace and the fixed trace, the horizontal axis is not only first translated to make the mean zero as above, but then a very small rotation is introduced to make the sum of the squares of the deviations from the zero line a minimum. This removes the effects of any slight rotational misalignment without interfering with the basic data.

It is believed that the above data processing techniques represent a minimum adjustment of the data, which consequently may be referred to as the basic "uncorrected" data.

Computer plots of the uncorrected data are included in a later section of this report. The three components of each record are shown, except for those records where fewer than three components were digitized. They appear in the same order as on the original record, so that it is not necessary that the vertical component be the third, as has previously been the case. The scales on the two axes are standard throughout, wherever possible, so that a quick glance shows immediately the relative amplitudes, and whether or not there were particularly high frequency or long period ground motions present.

The components mentioned, e.g. S44W, N46W, Up, indicate the direction of the transducer pendulum motion when moved by hand, for the trace to be deflected upwards on the record as it is viewed in the normal way with time increasing from left to right and the emulsion side up. This has been the standard practice since the strong-motion program began in the early thirties under the name of the Seismological Field Survey. A true ground acceleration, during earthquake motion, will be positive (or upwards) on these plots when in the opposite direction to these component labels.

Phase 2. - Corrected accelerations. The processing necessary to correct accelerograms includes the corrections for instrumental response and true baseline. Preliminary smoothing is carried out first. From the uncorrected accelerograms, digitized at unequally spaced points, equally spaced data with 100 points per second are interpolated. This is low-pass filtered using an Ormsby filter (Ormsby, 1961), having a cutoff frequency of 25 cps and a roll-off termination frequency of 27 cps. Decimation follows, selecting every second point, resulting in smoothed data with 50 points per second, corresponding to a Nyquist frequency of 25 cps.

The instrument correction affects particularly those frequency components higher than about 1/2 of the natural frequency of the instrument transducer, and is particularly important towards the upper limit of the frequency band retained, i.e., 25 cps. The correction is performed using the standard second-order differential equation governing oscillator motion together with the natural frequency and fraction of critical damping obtained from calibration tests of each accelerograph component. Differentiation of the instrumental response that is required for this correction is carried out by the simplest central difference method.

The baseline correction removes from the accelerogram all Fourier components with periods longer than an upper period limit chosen on the basis of careful tests. The upper limit for long hand digitized paper records has a cut-off period of 14 sec, and roll-off termination at 20 sec — the corresponding frequencies are 0.07 and 0.05 cps. This correction procedure, developed in the Caltech standard data processing project, replaces the earlier systems of baseline correction that consisted of the least squares fitting of a constant, a straight line, or a parabola, etc.

Recent experience with records shorter than approximately 60 seconds has shown that the upper limit for long periods must be selected with due consideration given to the record length. It is not advisable to assume that a satisfactory measure of the Fourier components with periods longer than 1/4 or 1/3 of the record length can be obtained from any record. Henceforth our standard procedure will include a check of the record length, and for records shorter than 60 seconds revised cut-off and roll-off termination periods are used. These restrict the periods retained in the corrected data to 15 seconds, or 1/4 the record length, whichever is smaller. The actual cut-off and roll-off termination frequencies, at both sides of the pass band, are indicated in the title of the Phase 2 results.

The details of the baseline correction may be found in the reports from the Caltech data processing project (see References, Phase 2) but in general terms the procedure is made up of the following steps:

1. Least square fit a straight line to the uncorrected acceleration as an initial baseline and initial correction to the acceleration.
2. Compute the velocity, assuming a zero initial value, and least square fit a straight line to the velocity.
3. Add the slope of this fitted line to the acceleration obtained in step 1.
4. Low-pass filter the acceleration of step 3 with a running mean filter, decimate it, and low-pass again with an Ormsby filter using the cut-off and roll-off termination frequencies given above (for 60 second records, the values are .07 and .05 cps). The remaining very long period components form the new baseline, which is subtracted from the accelera-

tion of step 3. This complete step consequently results in a high-pass filtered acceleration.

5. Again compute the velocity, assuming zero initial values, and least square fit a straight line to the velocity.
6. Incorporate the slope of this fitted line into the acceleration of step 4.
7. Apply the complete step 4 to the velocity of step 5, resulting in a high-pass filtered velocity and a particular initial value of the velocity.
8. Compute the displacement from the velocity of step 7, assuming a zero initial value, and apply the high-pass filter of step 4 to this displacement, which also results in a particular initial value of the displacement.

The instrument correction and baseline correction outlined above result in a corrected accelerogram which represents the acceleration of the instrument support in the frequency band between a particular low level frequency and 25 cps. The accuracy of the long period Fourier components of displacement has been extensively investigated (Hanks, 1973) using results obtained from the San Fernando earthquake. The accuracy is estimated to be somewhat better than 1 cm in the period range of 5-8 seconds, approximately 2 cm at periods near 10 seconds, and several (2-4) cm in the 10-15 second period range. It is quite likely here also in some of the displacement plots of phase 2 processing that some low amplitude long period noise may still be present. There are no components remaining with periods longer than those determined by the cut-off and roll-off termination periods, but it is evident that for some records this cut-off period is in fact too long if displacement errors are to be kept smaller than the estimates indicated above. The cause for this lies in the presence of noise arising primarily from random digitization noise, independent of the acceleration amplitudes. The very low amplitude of long period accelerations throughout the record therefore gives a low signal-to-noise ratio at these long periods. With this in mind, the displacement plots indicate that a cut-off period lower than that used could perhaps remove these components from the acceleration data. Routine processing of subsequent records will include the ability to make a preliminary selection of a cut-off period optimal for a particular record by viewing displacements during computing runs and phase 2 processing will incorporate this selection.

Computer printout of the corrected data of phase 2 are available from a companion tape to this report. The corrected acceleration is listed in units of mm/sec/sec, so that space-saving integers can be used, retaining the precision of the original digitizing machine, whose least count corresponds to about 3 mm/sec/sec. The equal time interval is 0.02 seconds. Identification labels, instrument characteristics, peak values, and initial values are included in the headings for each component. Plots of acceleration, velocity, and displacement are shown with axes and scales selected suitably to show the entire record. Peak values are indicated. The definition of component direction has been described previously for the phase 1 plots. For the phase 2 plots, the same component name is retained. But for the corrected data, in order for the component name to indicate the direction of positive ground acceleration, velocity, and displacement, the signs on the vertical axes have been changed. All ground motions, both portrayed in the plots and listed in tables, are now associated with a positive sign when in the direction of the named component direction, and such a motion is plotted downwards. As examples of this convention, if the vertical component is labelled "Down", then a phase 2 plot will present an actual <u>downward</u> ground displacement (or velocity, or acceleration) with a curve that is <u>down</u> below the axis. If a horizontal component is labelled "East", a phase 2 plot will present an <u>eastward</u> ground displacement (or velocity, or acceleration) with a curve that is <u>down</u> below the axis.

Phase 3 - Response spectra. An introduction to response spectrum techniques as they are commonly applied in the earthquake engineering field may be found in the references, particularly the Caltech report, Volume IIIA. The following remarks apply primarily to the influence of the data processing techniques on the computation of these spectra.

The component directions have been described in the earlier sections of phase 1 and 2. The spectral calculations of phase 3 are concerned with absolute values of response and the particular component sense is thus immaterial.

The earthquake response spectrum was originally introduced as a means of characterizing the response of structures to the exciting ground motion, and hence such spectra are calculated from ground motions. There are many instances, however, in which a structural motion is the excitation, for example, of mechanical equipment or other objects attached at upper story locations in buildings. In such cases it may be useful to calculate a response spectrum based on an acceleration-time function which is in itself a response to the earthquake ground motion. Such response spectra of the motion of a particular structure will ordinarily contain predominant peaks corresponding to structural frequencies and will consequently appear very different from ground spectra. The reader is cautioned to keep this point in mind and to avoid such building spectra when studying the characteristics of the ground motion itself.

Response spectra calculated from the corrected accelerograms of phase 2 are presented in the data section of the report. They represent the best combination of accuracy and frequency range that it is feasible to achieve with the currently available instrumentation and data processing. As future investigations improve these data processing techniques, and as more refined instruments make it possible to attain higher levels of accuracy and a wider frequency range, such calculations can no doubt be extended to take advantage of such improvements.

The long period noise described in the section on phase 2, and evident in some of the displacement plots appearing in this report, have an effect on the appearance of the phase 3 plots. Only experience can help in determining if the high spectral amplitudes at long periods correspond to the evident long period oscillations in some of the displacement plots. The extent to which long period noise plays a part in this behavior also becomes clear with experience and is discussed in the references under phase 2.

The phase 3 plots and printouts are presented later in this report, and on the companion tape, respectively. For each component there are two figures showing response spectra and two pages of tables containing the spectral ordinates. These are described in detail in the following paragraphs.

The first plot is that of the true relative velocity response spectrum, RV, with an identifying descriptive title. The five continuous line plots correspond to damping values of 0, 2, 5, 10 and 20 percent of critical and these curves will usually be easily distinguishable, with the zero damped curves having the greatest ordinates.

The dashed curve on this plot is the unsmoothed Fourier amplitude spectrum, FAS, calculated at the same periods as the relative velocity response spectra. The ordinates for the spectra are in units of cm/sec, whereas the scale is chosen to fill the available space. The periods extend to 15 seconds, close to the maximum long period cut-off point in the corrected data of phase 2, but the axis is divided into two separated linear portions. From 0 to 3 seconds takes up three-quarters of the axis, and from 3 to 15 seconds takes up the remainder.

The second plot is that of the pseudo velocity response spectrum, PSRV, together with the relative displacement spectrum, RD, and the pseudo acceleration spectrum, PSAA, in the tripartite logarithmic plot versus period. This convenient plot is made possible by the relationships between PSRV, RD, and PSAA:

$$PSRV = (2\pi/T)\ RD$$

$$PSAA = (2\pi\ /T)^2 RD$$

The units used are cm/sec, cm, and g.

The corresponding tape contains values of the ordinates for the previous plots. First is listed the Fourier amplitude spectrum (FAS), and then five sets of four arrays containing RD, RV, PSRV, and absolute acceleration spectra (AA) for all of the five damping values.

Phase 4 Fourier spectra. As indicated earlier in this section, the Fourier spectra calculated by fast Fourier transform subroutines are not included in this report. They will be incorporated in a subsequent report devoted solely to Fourier spectra.

Phase 5. Time-dependent Spectral Analysis. The response spectrum was first introduced into earthquake engineering by Benioff (1934) and refined by Biot (1941). With improvement and refinement by others (Alford et al., 1951; Housner et al., 1953; Hudson, 1956), this technique has become an important tool in the design of earthquake resistant structures when dealing with buildings of simple design and special structures such as elevated water tanks. The response of each mode of multi-degree-of-freedom systems such as tall buildings, chimneys or towers can be calculated utilizing the same equation of motion used to obtain response spectra. Each modal response can then be superposed to obtain the total response of the system (Merchant and Hudson, 1962). When the approximate design method utilizing response spectra is not sufficiently accurate and the more involved and costly technique of time-history dynamic response is needed, a response spectrum can be used for the preliminary design. Considering the importance of the response spectrum in seismic engineering, a maximum amount of information should be extracted from it. One method involves the study of response as a function of time (Perez, 1973a; Trifunac, 1971; Hays et al., 1973; Blume and Associates, 1973).

The response spectrum is a plot of the maximum response of a single-degree-of-freedom oscillator, subjected to the particular earthquake, for a given damping factor and for a spectrum of frequencies. However, this focusing on the maximum value ultimately ignores any relationship that exists between the time history of the response and the ground motion. In particular, no information is retained on the difference in time between the strongest part of the ground motion and the strongest part of the resulting response. This type of relationship can be qualitatively investigated using time-dependent spectral analysis, which helps in understanding the effects of high levels of ground acceleration on the response spectrum (Perez, 1973b). The understanding of high levels of ground acceleration is critical, as values have been recorded as high as 1.25 g for Pacoima Dam in 1971 (Trifunac and Hudson, 1971), and 0.7 g for Melendy Ranch in 1972 (Morrill et al., 1974). It can be expected that higher peak accelerations will continue to be recorded.

Important structural engineering information can be obtained by studying in detail the length of time that the general level of velocity response, as indicated by its envelope, is greater than particular predetermined levels. Although certain levels of shaking may do minimal damage to structures at the onset of an earthquake, prolonged shaking at those levels could cause extensive damage due to progressive failure. At the present time, the correlation of building damage versus levels of response and their respective time duration has not been developed. However, attempts in these two areas are being made by several investigators. For example, Matthiesen and Rojahn (1972) have made estimates of threshold structural damage levels for various classes of buildings. The structural response duration at different levels and its relation to structural damage by low-cycle fatigue has been studied by Kasiraj and Yao (1968); Suidan and Eubanks (1973) have studied the cumulative fatigue damage in seismic structures; Popov and Bertero (1973) have studied cyclic loading of steel beams and connections.

The Velocity Response Envelope Spectrum (VRES). This section describes the construction of the contour plots of the velocity levels attained by the velocity response envelopes. These contour plots are not included in this report, but a representative sample is shown in Figure 1. The data represented by the plots are

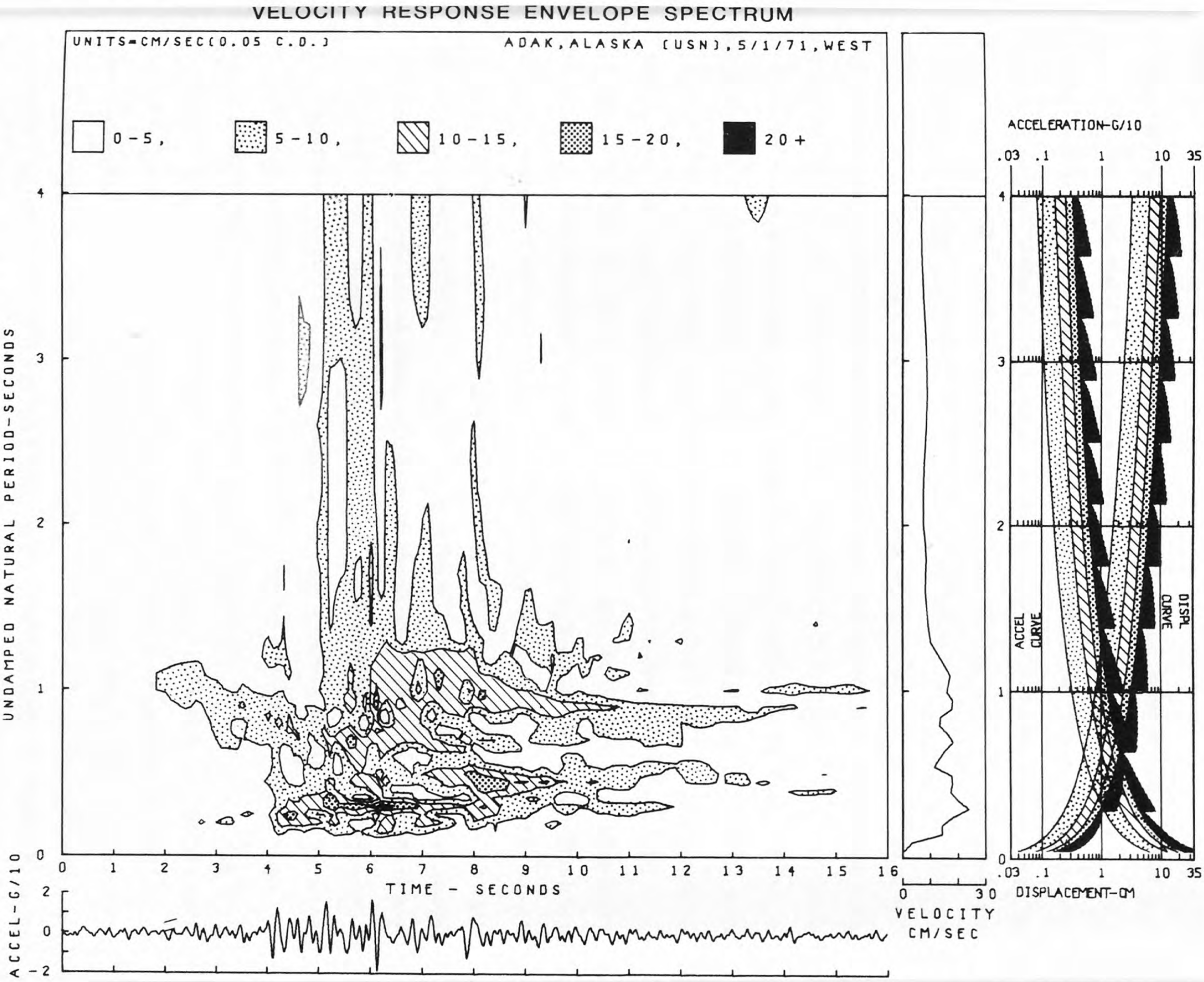

Figure 1.- The contour plot, time history, response spectrum and representative nomograph of the Velocity Response Envelope Spectrum.

used in the Time Duration Spectra of the next section. The original response spectrum is based on the response of the single-degree-of-freedom, viscously-damped, linear oscillator subjected to earthquake ground motion. Such an oscillator acts as a narrow-band filter which amplifies the input frequencies centered around the natural frequency of the oscillator (Trifunac, 1971). To study the response as it varies with time, the envelope of the response is used instead of the actual response. The envelope contains all of the important information required to calculate the maximum relative velocity as normally defined, while maintaining the history of the response as it varies in time. For any particular oscillator those times at which the envelope of the oscillator response rises above or falls below predetermined velocity levels are noted and the results can be plotted in the VRES two-dimensional contour plots as shown in Figure 1.

The following method was used to calculate the VRES as a two-dimensional function of time and natural period. The oscillator response was computed for 41 natural periods. The periods selected were: 0.05, 0.075 seconds; from 0.1 to 1.0 seconds at 0.05 second intervals; from 1.0 to 2.0 seconds at 0.1 second intervals; and from 2.0 to 4.0 seconds at 0.2 second intervals. This scheme was chosen to obtain an appropriate density distribution at the higher frequency end of the spectrum. For each period the response envelope was approximated by connecting the absolute value of the local peaks of the response curve. The envelope curve was then interpolated at 160 equal intervals regardless of length of time (i.e. if length of time was 16 sec, then interpolation interval was 1/10 sec). Levels were chosen according to the maximum response, with no more than six levels, regardless of amplitude.

These 41 periods, with their respective VRES calculated at equal time intervals, represent a rectangular grid of spectral values. Contours of equal amplitude were produced by plotting interpolated values from the grid, giving a contour map of the VRES amplitude values as a function of time and period. The maximum relative velocity response spectrum is plotted to the right of the contour map. The contour map shows the peaks and valleys of the VRES as a function of time and period, while the maximum relative velocity response spectrum shows the silhouette of the peaks. The input acceleration is plotted below the contour map to show the relationship between acceleration and the VRES as they vary in time.

In most instances, connecting the local peaks of the relative response is a good approximation to the response envelope (Perez, 1974). In some instances, the high frequency content in the relative response gives an envelope of these high frequencies and not of the period being analyzed. A better approximation to the envelope of the response would be obtained by filtering out frequencies appreciably higher than the ones being studied, without altering either the phase or the magnitude of the response of a given oscillator. Since filtering would eliminate the high frequency information that exists in the relative response of longer period oscillators, and since the VRES plots can easily be inspected when these high frequencies are present, no smoothing of the response is contemplated at the present time.

Displacement and Pseudo-absolute Acceleration Response Envelope Spectrum (DRES AND ARES) Time-dependent spectral analysis may be expressed not only as relative velocity (VRES), but also as relative displacement (DRES) and absolute acceleration (ARES). Relative displacement is important because the shear force exerted by the columns of a structure on the ground are directly proportional to the relative displacement. The absolute acceleration is a measure of the seismic forces acting on the mass of a structure.

A partial solution to obtain VRES, DRES, and ARES is to approximate these quantities through a calculation commonly used by structural engineers. If the response is assumed to be approximately sinusoidal, then the displacement response can be approximated by dividing the velocity response by $\omega_o = 2\pi/T_o$ (T_o is the natural period of the oscillator) and the absolute acceleration response can be approximated by multiplying the velocity by ω_0. Because velocity response is calculated as a function of time for specified levels, a nomograph may be constructed with curves relating velocity to the corresponding values of displacements and pseudo-absolute accelerations. The method is somewhat similar to the tripartite logarithmic plots used by structural engineers. The curves of the nomograph are based on the different levels of the relative velocity response envelope as a function of time. Note the ordinate of the nomograph on the right of the VRES plot of Figure 1 is drawn to the same scale as the contour map and the maximum velocity response spectrum. The left side of the nomograph's contour level represents the lower velocity ranges. An example of using the nomograph is as follows: for a velocity level of 2.5 cm/sec and 3.0 second period, the equivalent pseudo-absolute acceleration is about 0.005 g; for the same velocity level and same period, the equivalent displacement is about 1.2 cm.

The damping of structures undergoing small amplitude oscillations is generally found to be in the range of 1 to 5 percent critical damping; for structures behaving in the nonlinear and plastic range, the damping can be 10 percent or more (Trifunac, 1971). In this analysis, 5 percent critical damping was used in calculating the VRES.

Since the period range for the VRES is between 0.05 and 4.0 seconds, harmonic theory indicates that the response delay to any significant pulse should be no more than 0.0125 to 1 second (i.e., period/4). However, an examination of the VRES and the acceleration record incorporated alongside shows that the maximum acceleration and the maximum velocity response need not be separated by this delay time interval (Perez, 1974).

Time Duration Spectrum of the Response Envelope. From an engineering point of view, it is important to study not only the peak response and time of occurrence, but also the time duration above a given level of response (Perez, 1973a). The time duration spectrum is defined as the cumulative total time that the VRES equalled or exceeded a given level during the entire acceleration record. In the time duration spectra plots, the levels of response chosen are identical to those chosen for the computation of the VRES plots. The total time duration of different amplitude levels of the VRES can also be expressed in terms of the number of cycles that occurred at or above a particular level. Due to the filtering properties of a simple harmonic oscillator, the dominant period of the velocity response is approximately equal to the natural period of the oscillator. Therefore, by dividing the duration by the period of the oscillator, a family of straight lines indicating the number of cycles for a given velocity response level can be generated.

The envelope levels of the velocity response may be converted to corresponding envelope levels of displacement and pseudo-absolute acceleration response by calculation or by a nomograph similar to that of Figure 1. Because approximate sinusoidal motion is assumed for the velocity response, the time duration and the number of cycles for a given amplitude level also hold true for the corresponding levels of the displacement and the pseudo-absolute acceleration response envelope.

SUMMARY OF RECORDS INCLUDED IN THIS REPORT

This report contains plots of the data reduction and spectral analysis of ten selected strong-motion earthquake accelerograms recorded in five different stations, generated by seven chosen earthquakes that occurred in Peru during the period January 31, 1951 through November 9, 1974. Information on the earthquakes, stations, and records are summarized in Tables 1, 2, and 3, respectively, which include sufficient cross-referencing data. Plots of uncorrected accelerograms; corrected acceleration, velocity, and displacement; spectra for velocity response, pseudo-velocity response, and Fourier amplitude; duration of velocity response envelope, for each of the components of the records studied are presented in the set of figures in this report.

The high frequencies present in these Peru records have shown rather clearly in detailed plots that 50 points per sec is not a dense enough data rate for accurate representation of high frequency content. For the Peru records, the effect is most visible when the peak values of the uncorrected stage 1 data are compared with the corresponding values of the same points after stage 2 analysis. The relevant procedures include (a), interpolation at 0.01 sec which does not retain most peaks; (b), filtering out data above 25 Hz; (c), decimation to 0.02 sec which further cuts the high frequency peak values; and (d), the instrument correction, which in general will amplify any high frequency content. The overall effect on actual peak values is governed by (c), with the result that peak values can be severely reduced by the stage 2 processing, as initially pointed out by Hudson in the Index Volume to the Caltech Strong Motion Earthquake Accelerograms reports. The effect on the frequency content for these Peru records, as indicated by the stage 3 spectral processing, is not significant.

Recent data reduction of short duration accelerograms - as experienced in aftershocks, or accelerograms with high frequency content as indicated above in the Peru records - strongly suggests that digitizing density must be increased (a difficult procedure when manually digitizing is involved) and that filtering techniques must be revised to improve the representation of corrected acceleration. Unfortunately new techniques required time to develop and would cause delays in the dessimination of data. The intent of this report is to furnish data using present available techniques so as not to unduly delay accessibility of data to all interested parties.

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Table 1

EARTHQUAKE DATA

Eq. No.	Location	Date	Origin Time	Epicenter	Depth (km)	Mag.	Max MMI	Felt Area	Records
1	West Central Peru coast	31 JAN 51	11:38 (local)	12° S 78° W	-	-	-	-	1
2	Off Peru coast	17 OCT 66	16:41 (local)	10.7° S 78.7° W	-	7.5	At sea (IX)	-	2
3	Off Peru coast	31 MAY 70	15:23 (local)	9.2° S 78.8° W	56	7 3/4	At sea (VIII)	40,000 sq mi	3
4	Off Peru coast	29 NOV 71	-	11.2° S 77.8° W	-	5.3	-	-	4
5	Near Peru coast	5 JAN 74	08:33:12.3 (UTC)	12.3° S 76.4° W	98(GS)	6.6(PAS) 6.3(GS)	-	-	5, 6
6	Near Peru coast	3 OCT 74	14:21:29.1 (UTC)	12.3° S 77.8° W	13(GS)	7.5(PAS) 7.6(BRK)	At sea (IX)	-	7, 8
7	Near Peru coast	9 NOV 74	12:59:49.8 (UTC)	12.5° S 77.8° W	6(GS)	6.2(PAS) 6.9(BRK) 7.2(GS)	At sea (IV)	-	9, 10

Notes:

PAS: Seismological Laboratory, Caltech, Pasadena
BRK: Seismographic Station, UC Berkeley
UTC: Coordinated Universal Time
GS: USGS Preliminary Determination of Epicenters

Table 2

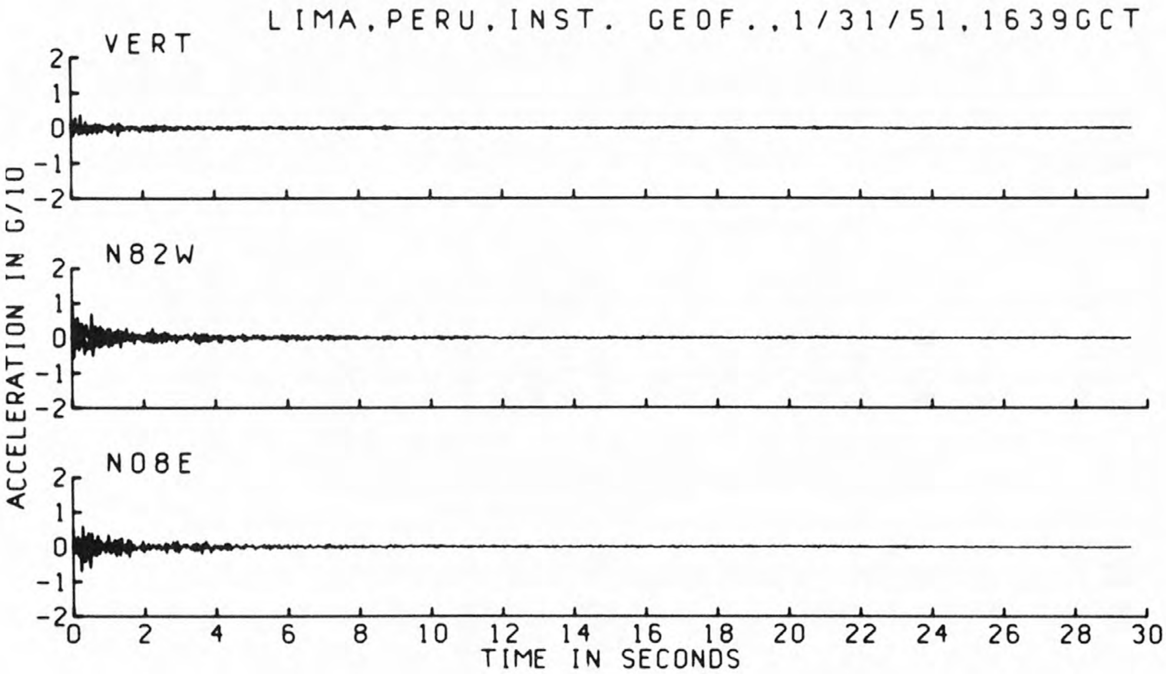
STATION DATA

Station No.	Identification Name	Coords.	Instr. type	Structure type/size	Instr. location	Records
4300	Lima Geological Inst. Plaza Habich	12.07 S 77.04 W	STD	2-story bldg	Ground level	1
4302	Lima Geophysical Inst. Avenida Araquipa	12.07 S 77.04 W	STD	1-story bldg	Ground level	2,3,4,5, 7,9.
4303	Lima Zarate Station	12.02 S 77.01 W	SMA	-	Ground level	6.
4304	Lima Casa Huaco Las Gardenias	12.13 S 76.98 W	SMA	2-story house	Ground level	8.
4305	Lima La Molina	12.08 S 76.95 W	SMA	2-story bldg	Ground level	10.

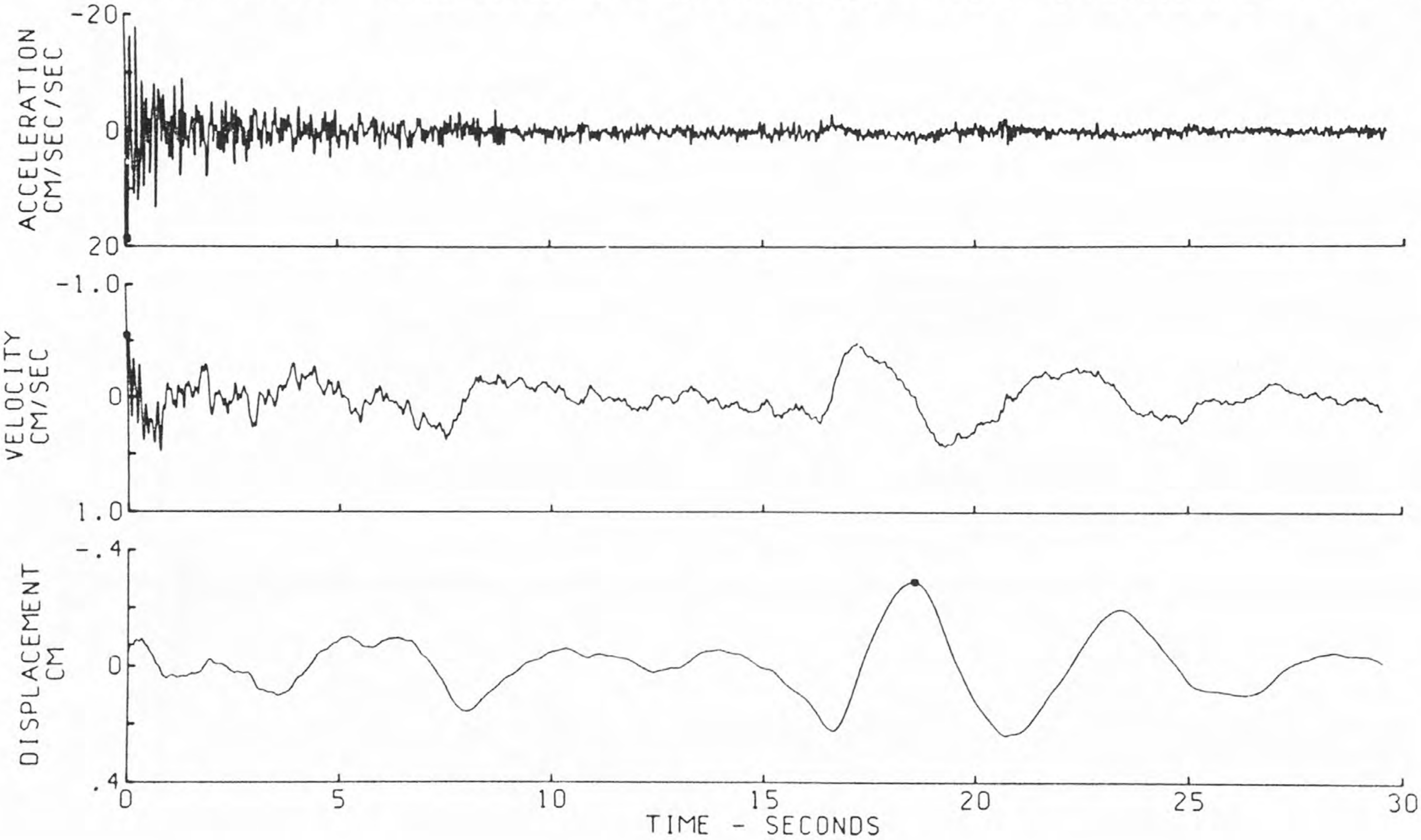
Table 3

RECORD DATA

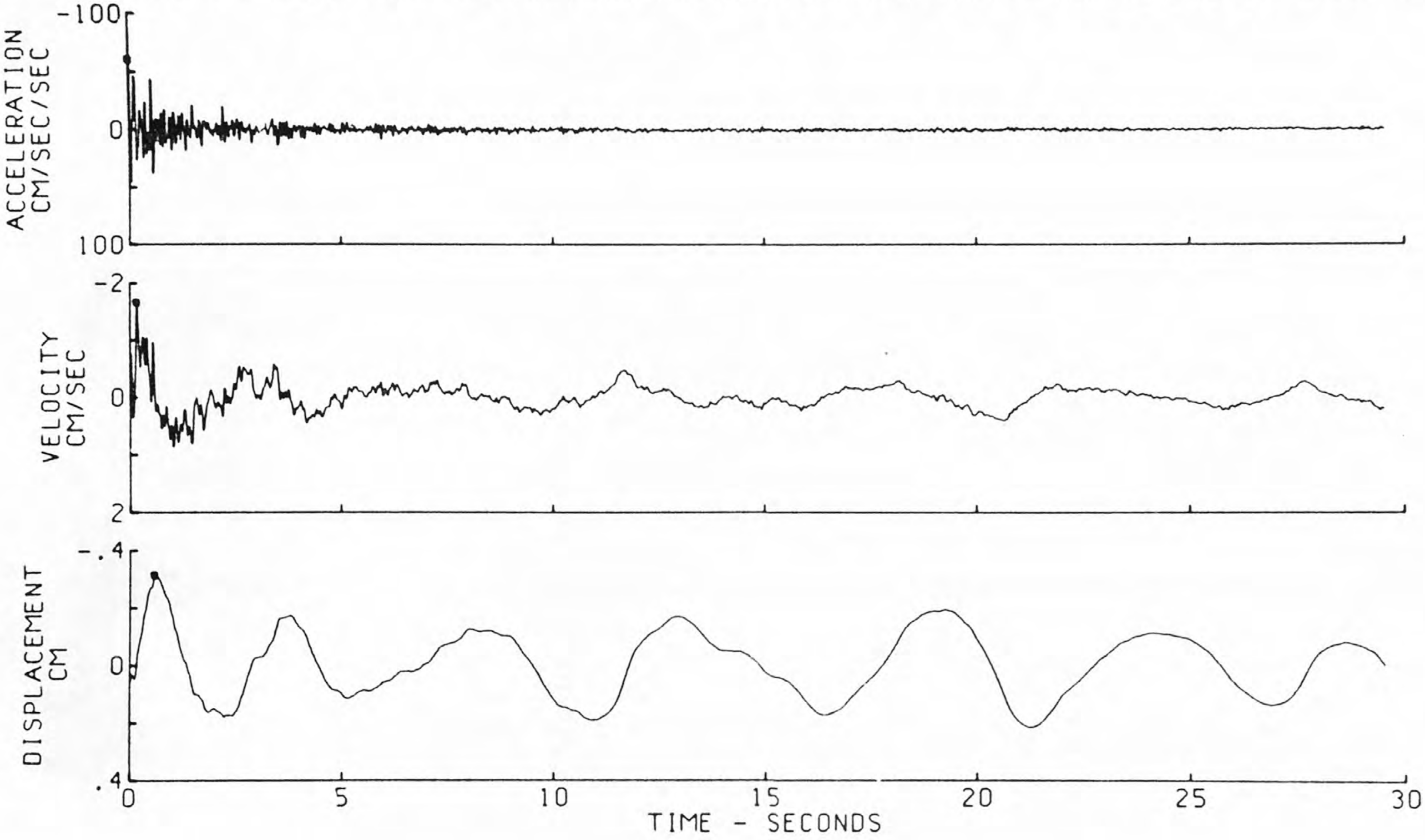
No.	Date	Eq. No.	Station	Stn. No.	Δ(km)	MMI	Comp.	Sens. cm/g	Period (sec)	Damp fraction	Dig'd length (sec)
1	31 Jan 51	1	Lima	4300	105	-	V:Up	13.2	.064	.50	30
			Geol. Inst.				L:N82W	12.8	.064	.55	
							T:N08E	12.9	.064	.40	
2	17 Oct 66	2	Lima	4302	236	VII	V:Up	12.4	.065	.53	66
			Inst. Geoph.				L:N82W	12.6	.064	.55	
			del Peru				T:N08E	12.5	.064	.59	
3	31 May 70	3	Lima	4302	372	-	V:Up	12.3	.066	.62	45
			Inst. Geoph.				L:N82W	12.9	.065	.61	
			del Peru				T:N08E	12.9	.066	.55	
4	29 Nov 71	4	Lima	4302	127	-	V:Up	12.4	.065	.55	40
			Inst. Geoph.				L:N82W	12.9	.065	.61	
			del Peru				T:N08E	12.9	.066	.56	
5	5 Jan 74	5	Lima	4302	74	-	V:Up	12.3	.065	.55	36
			Inst. Geoph.				L:N82W	12.9	.065	.61	
			del Peru				T:N08E	12.9	.066	.55	
6	5 Jan 74	5	Zarate Stn.	4303	73	-	V:Down	1.9	.038	.54	33
							L: -	1.9	.037	.54	
							T: -	1.9	.038	.53	
7	3 Oct 74	6	IGP, Lima	4302	86	-	V:Up	12.3	.063	.61	90
							L:N82W	12.9	.064	.60	
							T:N08E	12.9	.065	.57	
8	3 Oct 74	6	Las Gardenias	4304	91	-	L: -	1.9	.037	.54	90
			Huaco Res.				V:Down	1.9	.038	.54	
							T: -	1.9	.038	.54	
9	9 Nov 74	7	IGP, Lima	4302	95	-	V:Up	12.9	.065	.59	48
							L:N82W	12.9	.065	.61	
							T:N08E	12.9	.066	.59	
10	9 Nov 74	7	La Molina	4305	103	-	L: -	1.80	.038	.54	40
							V:Down	1.82	.039	.54	
							T: -	1.97	.039	.54	


LIMA, PERU, INST. GEOF., 1/31/51, 1639GCT
VERT
N82W
N08E
ACCELERATION IN G/10
TIME IN SECONDS
2
1
0
-1
-2
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30

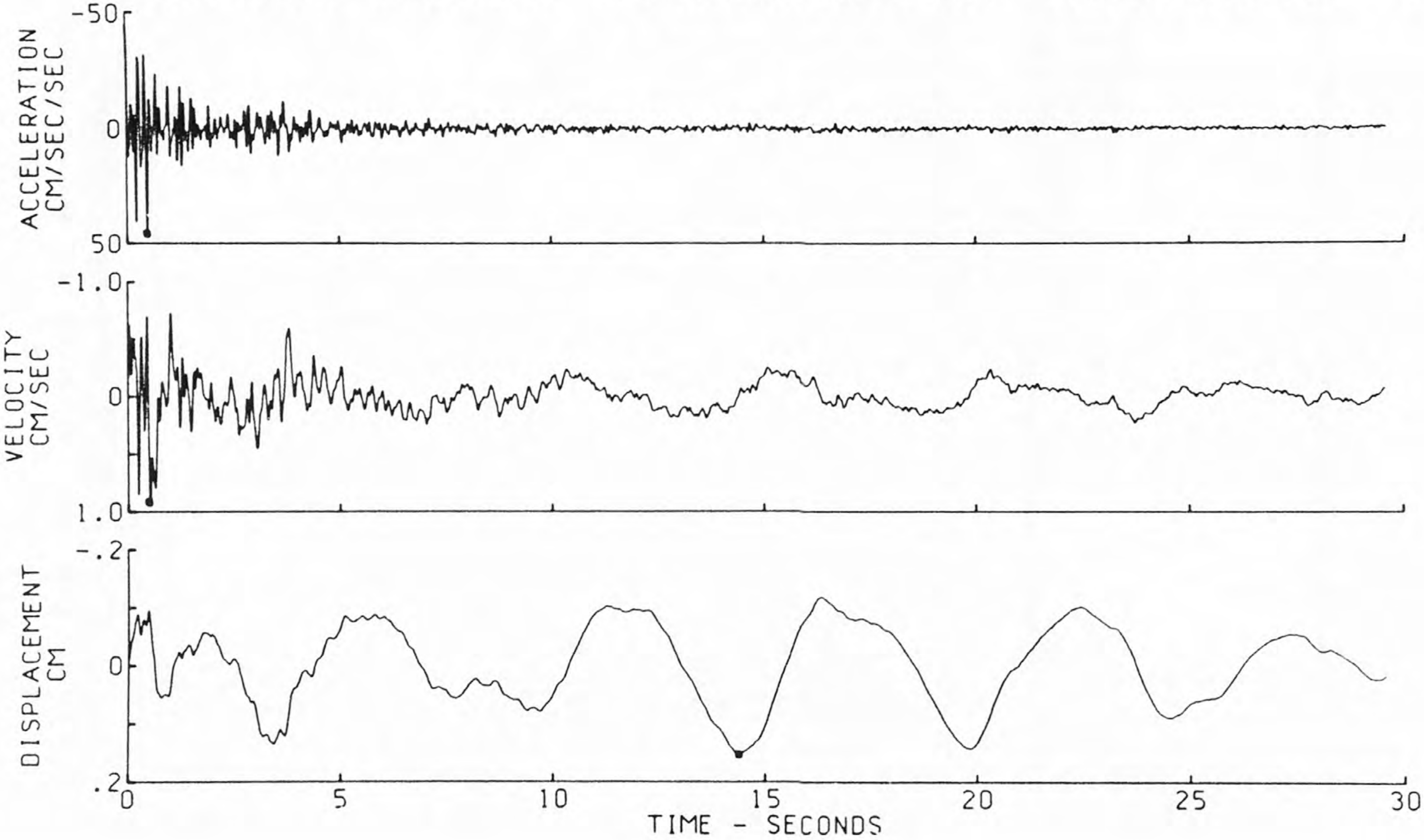
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF JANUARY 31, 1951 - 1639 GCT
INSTITUTO GEOFISICO DEL PERU, VERT COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .127 - .167 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=18.66 CM/SEC/SEC, VELOCITY=-.540 CM/SEC, DISPL=-.290 CM



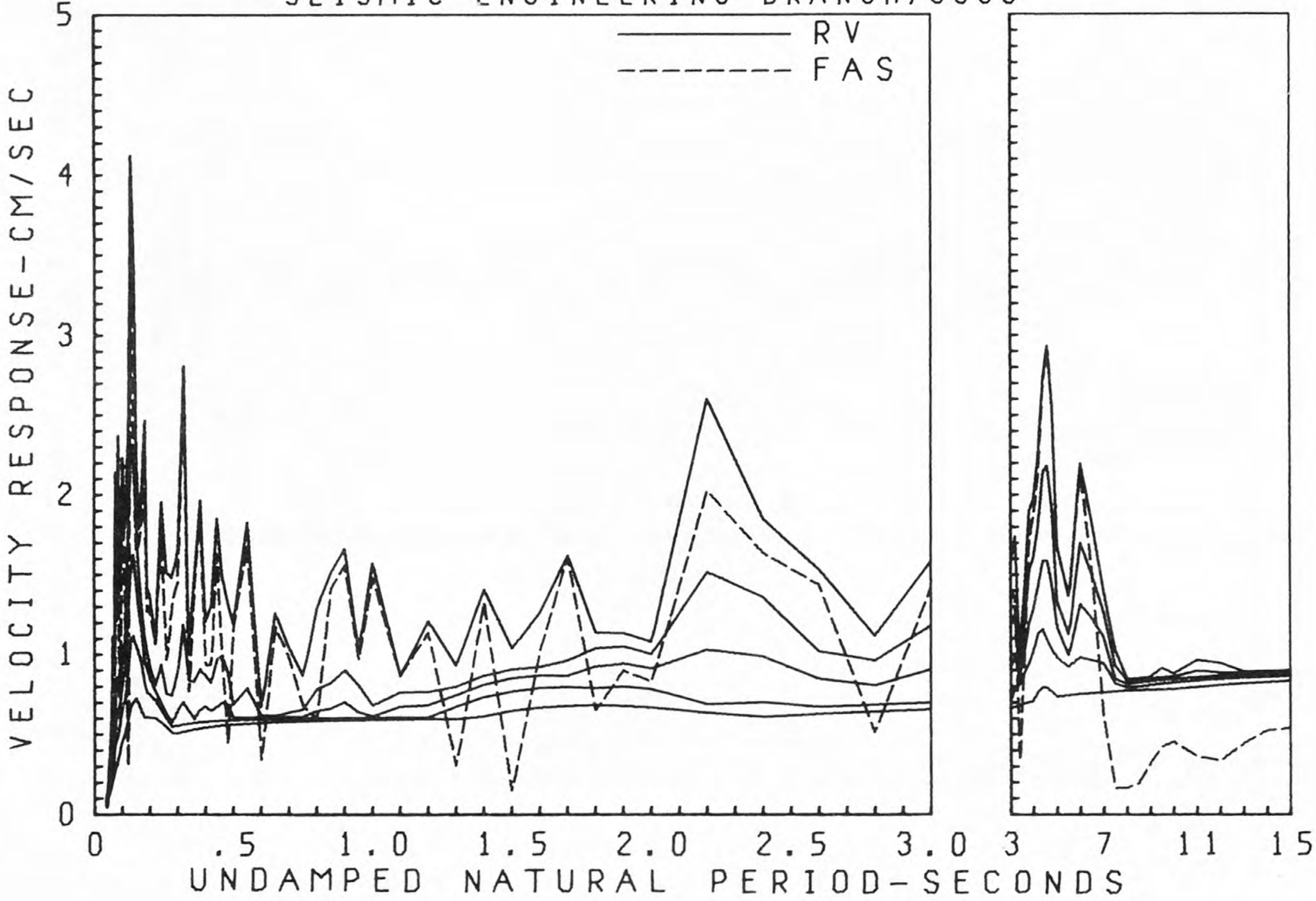
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF JANUARY 31, 1951 - 1639 GCT
INSTITUTO GEOFISICO DEL PERU, N82W COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .127 - .167 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-60.44 CM/SEC/SEC, VELOCITY=-1.650 CM/SEC, DISPL=-.310 CM

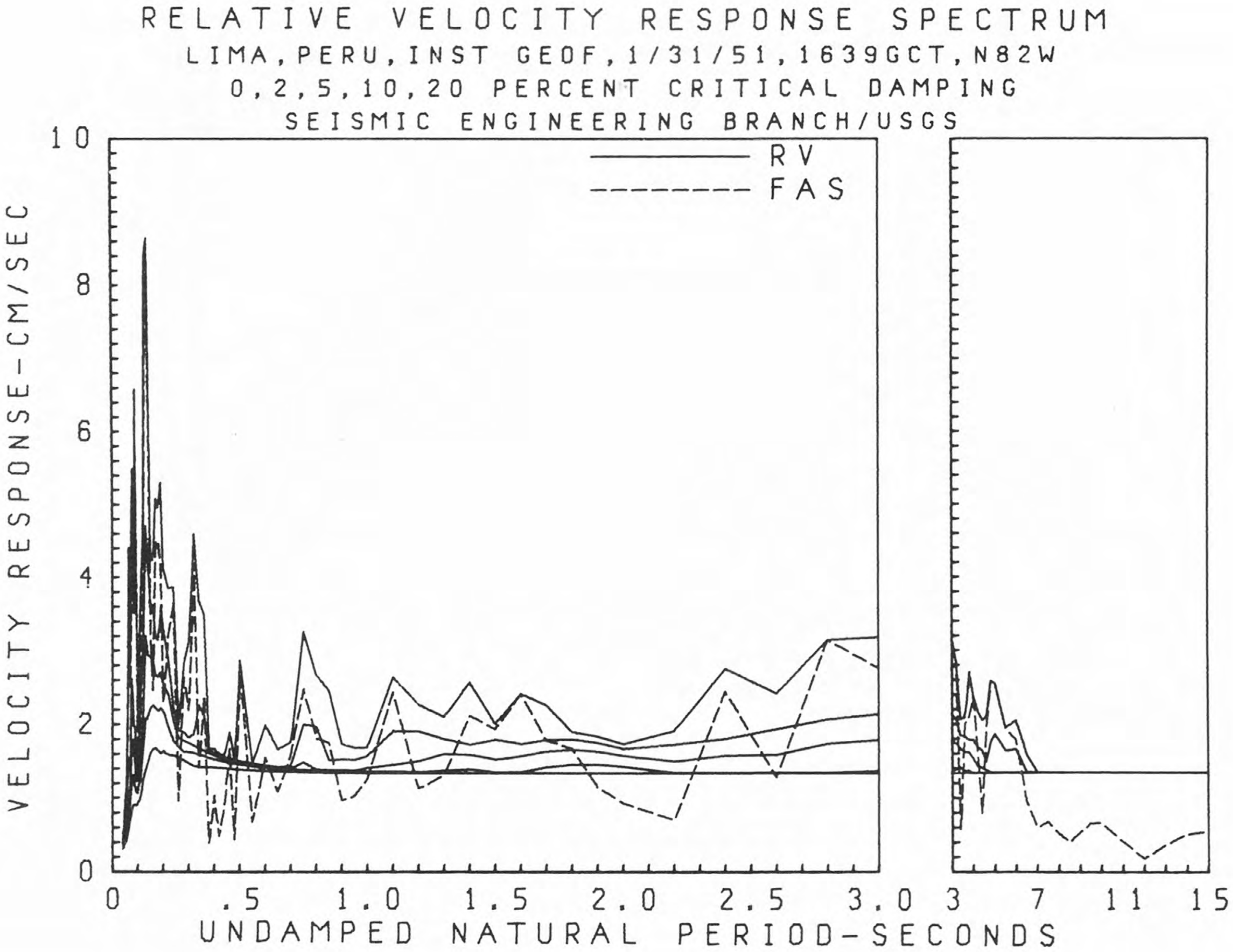


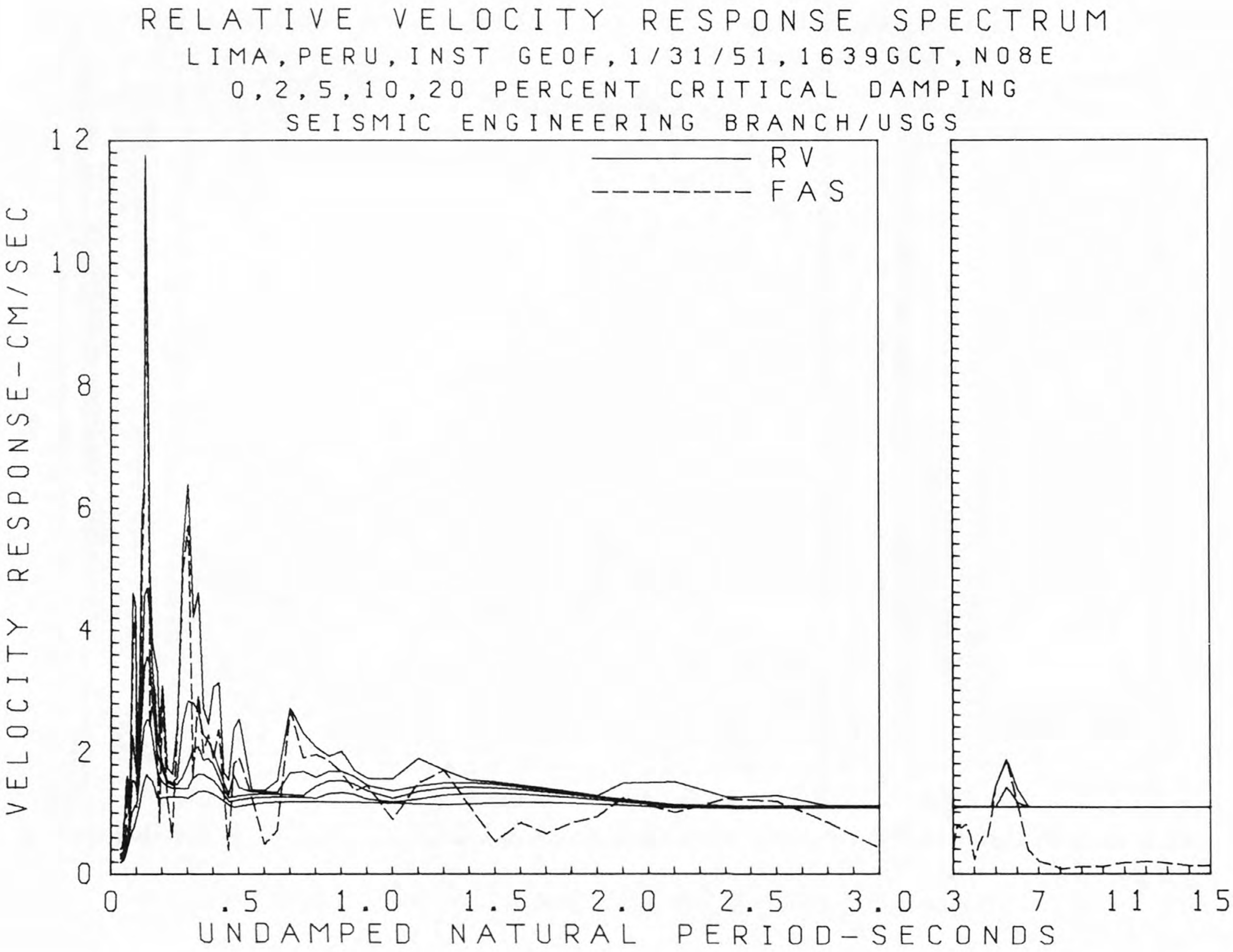
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF JANUARY 31, 1951 - 1639 GCT
INSTITUTO GEOFISICO DEL PERU, N08E COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .127 - .167 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=45.70 CM/SEC/SEC, VELOCITY=.920 CM/SEC, DISPL=.150 CM



RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST GEOF, 1/31/51, 1639GCT, VERT
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

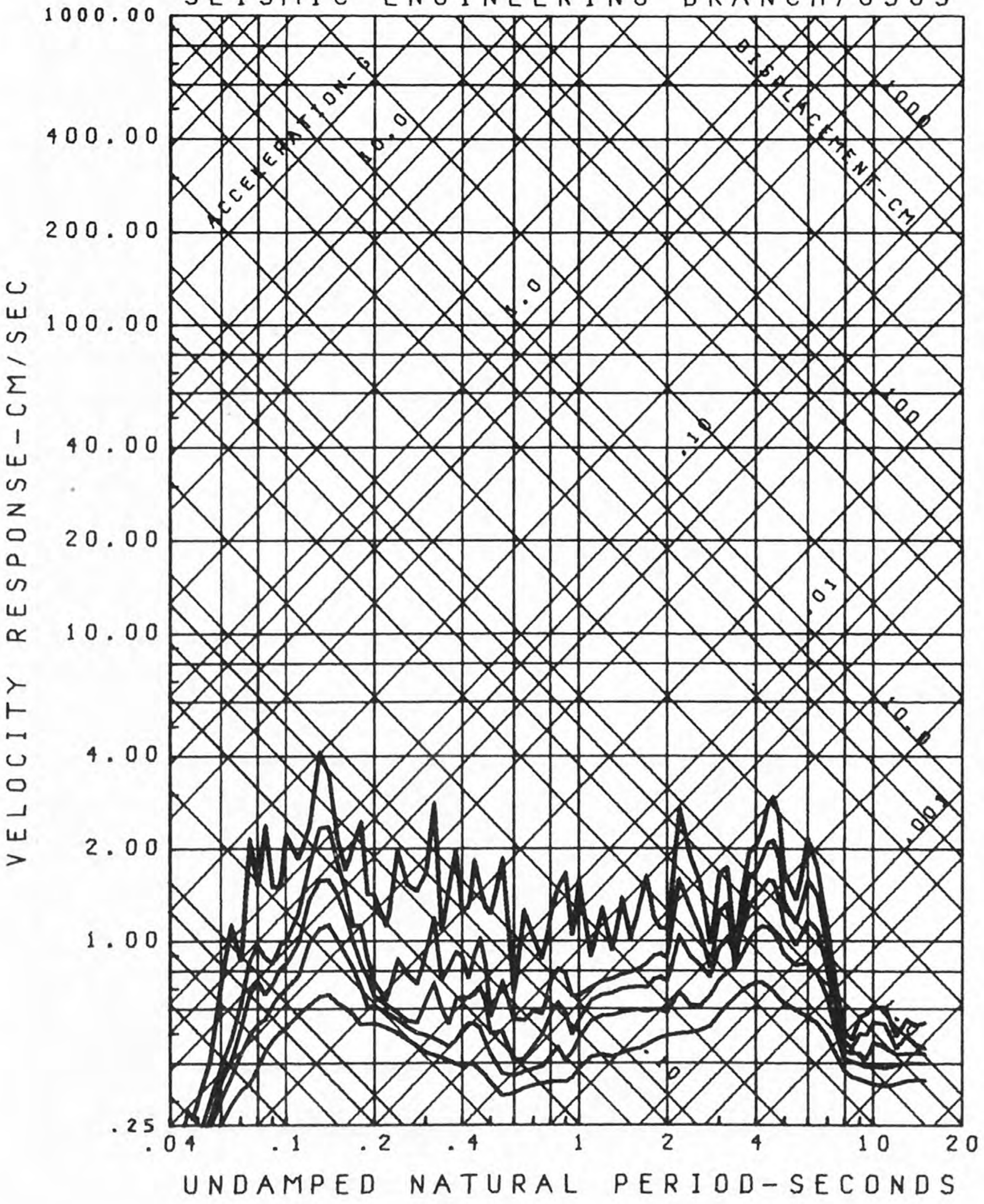


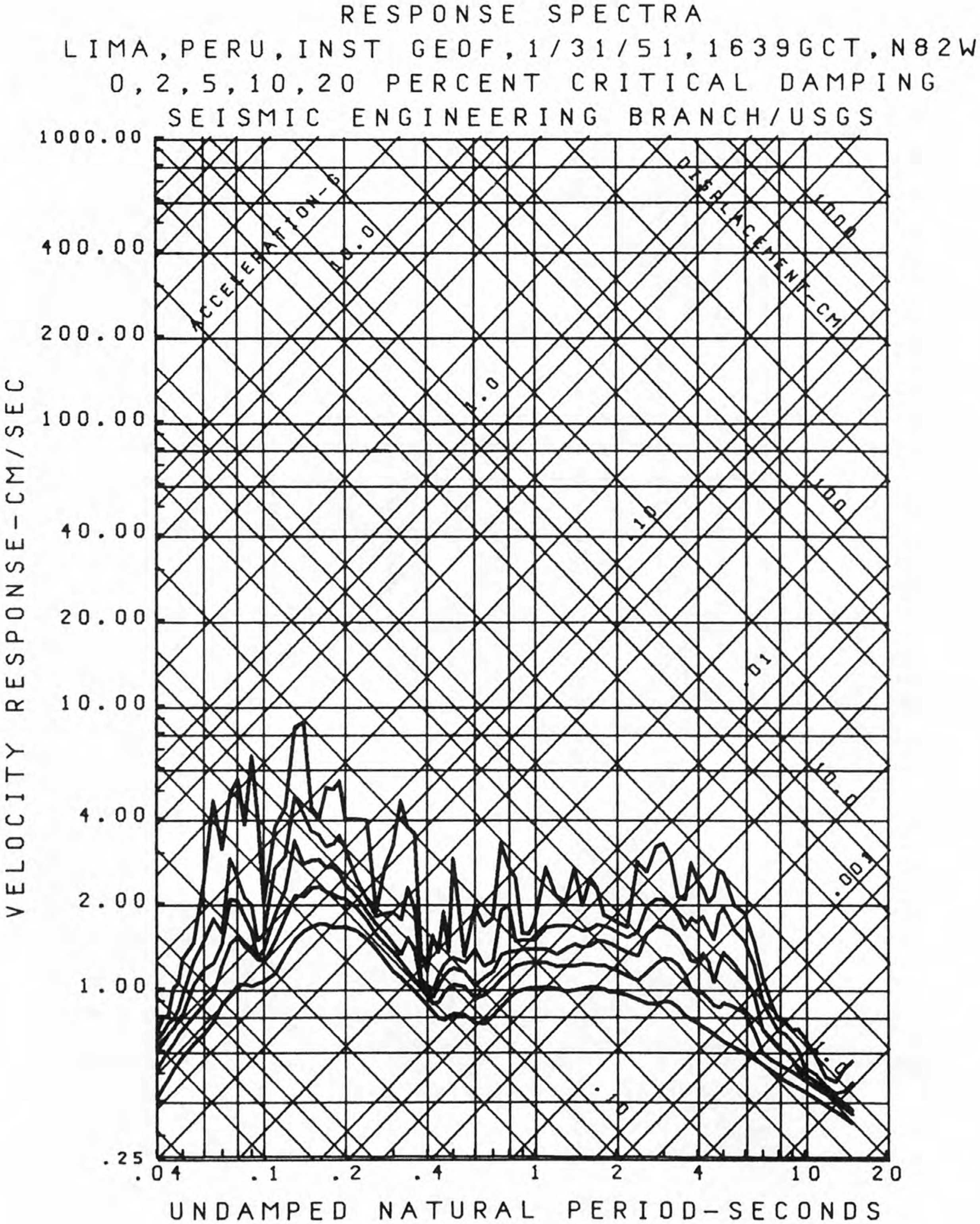

RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST GEOF, 1/31/51, 1639GCT, N82W
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
0
2
4
6
8
10
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

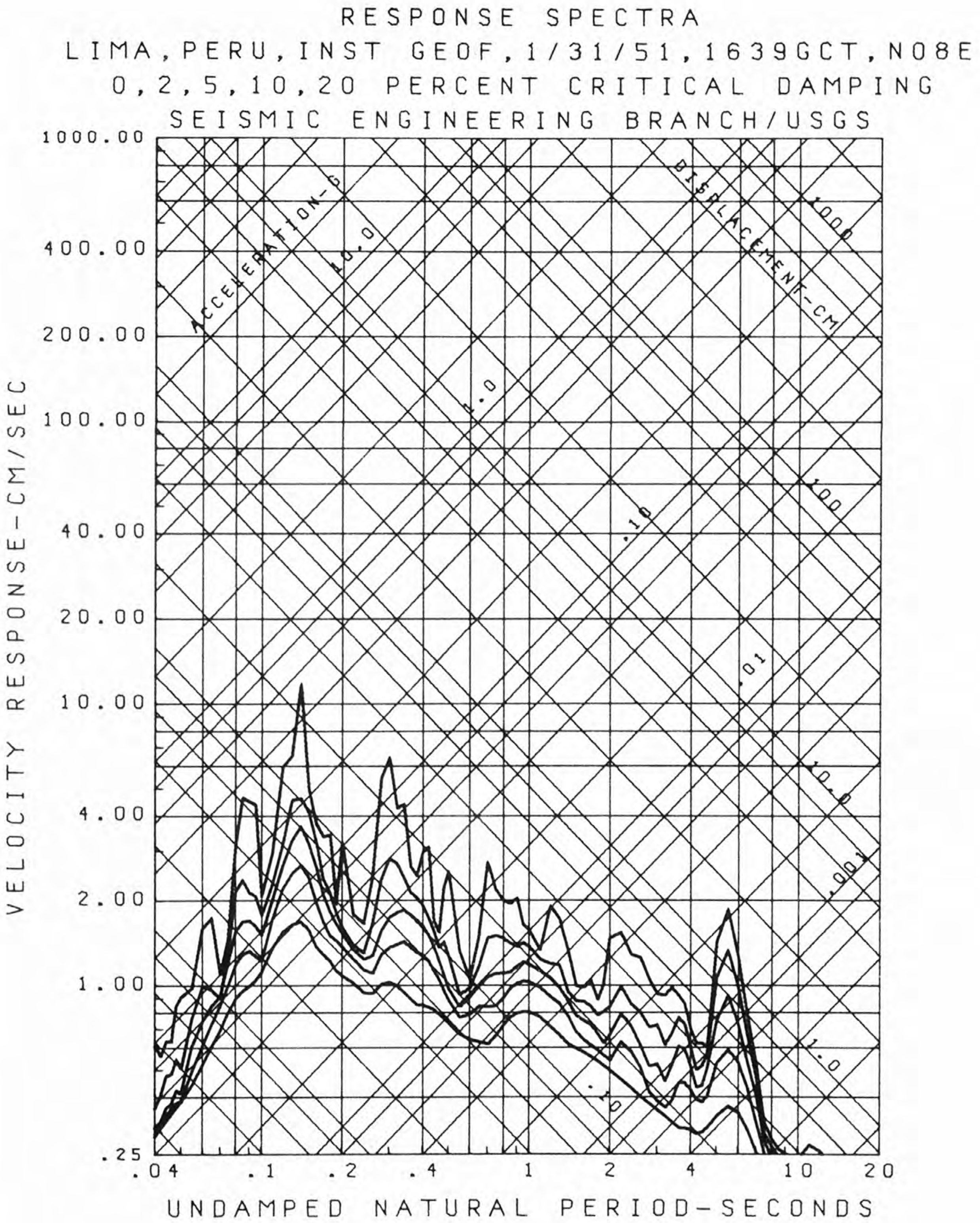


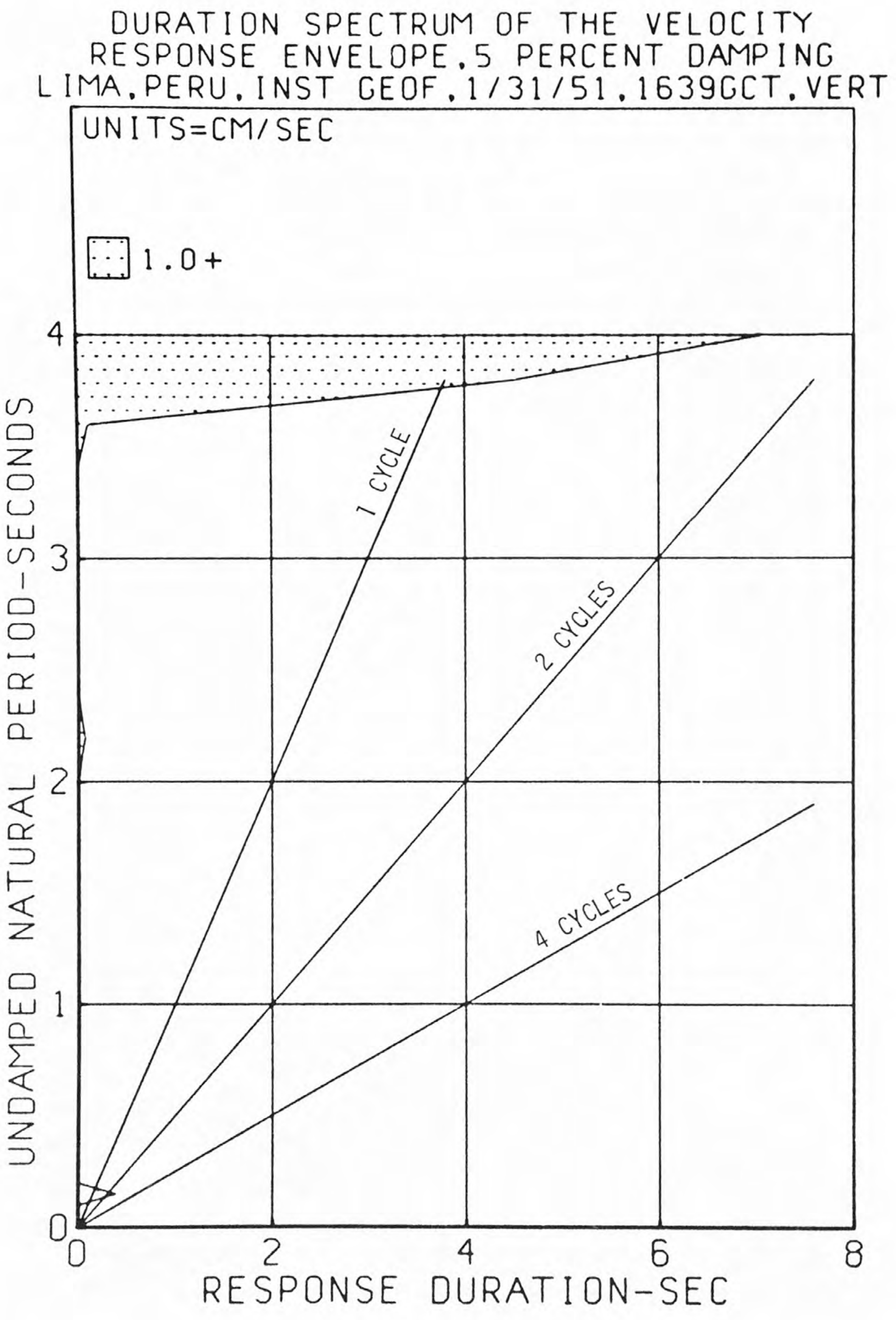
RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST GEOF, 1/31/51, 1639GCT, N08E
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
0
2
4
6
8
10
12
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

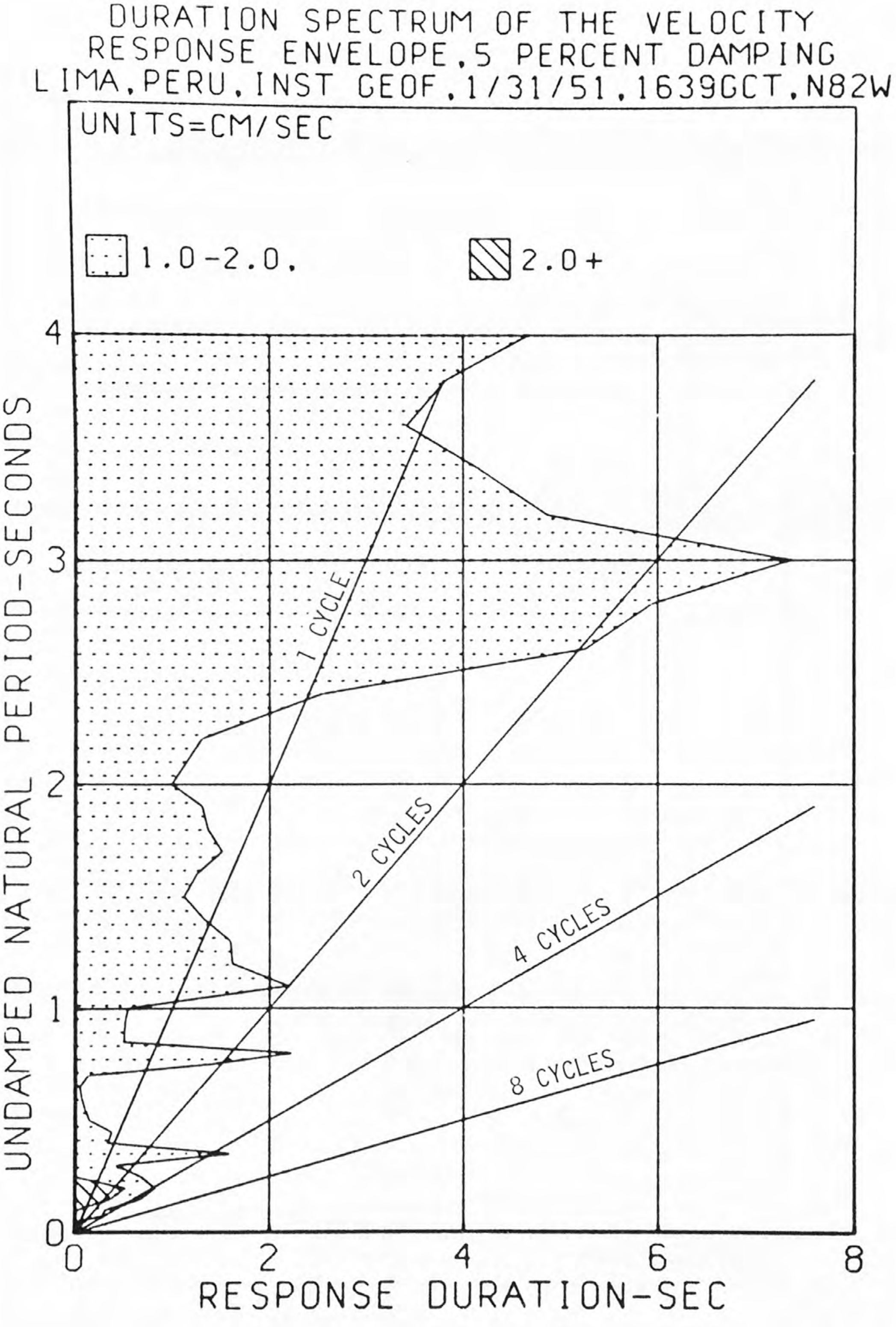
RESPONSE SPECTRA
LIMA, PERU, INST GEOF, 1/31/51, 1639GCT, VERT
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS



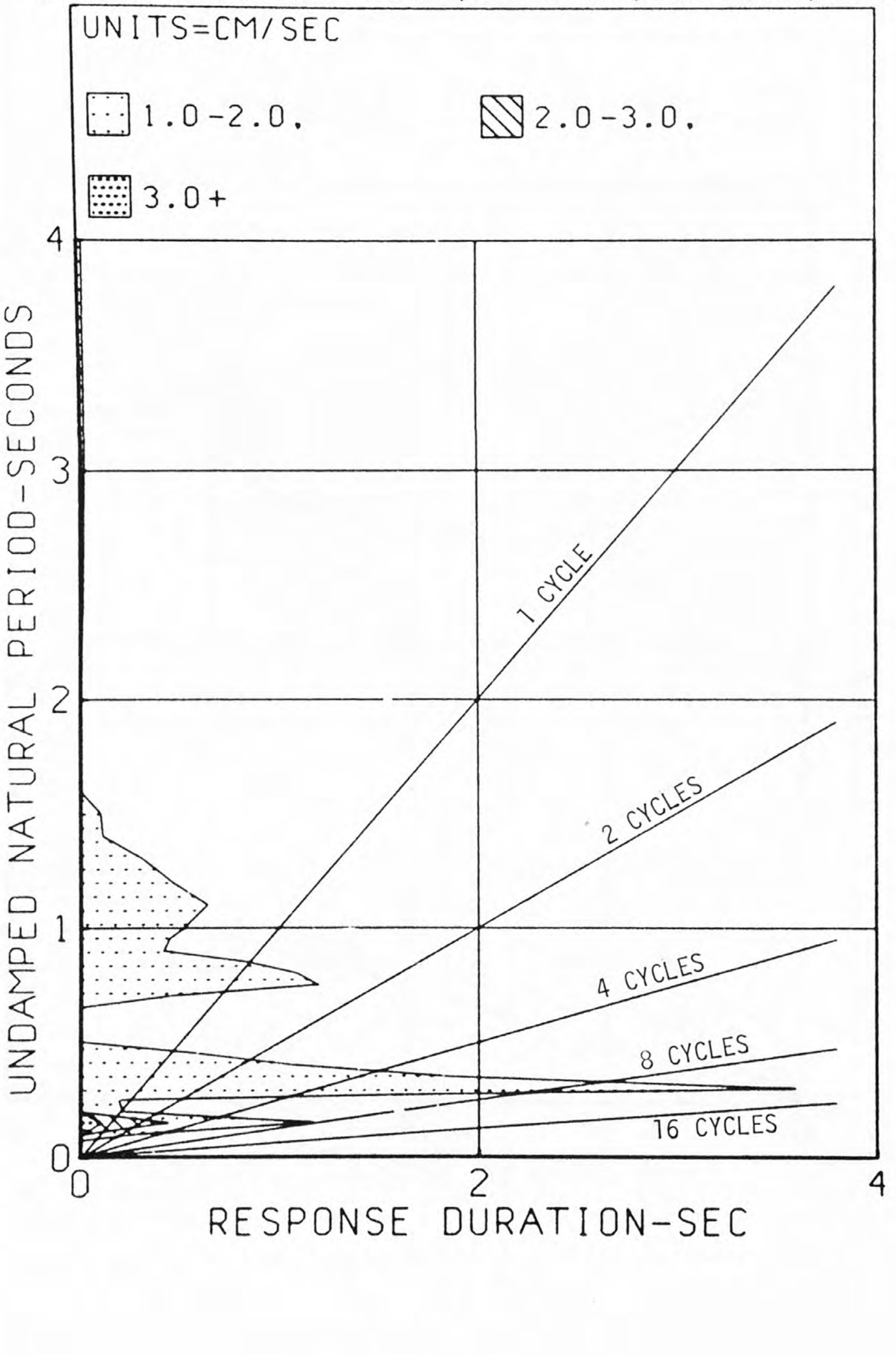

RESPONSE SPECTRA
LIMA, PERU, INST GEOF, 1/31/51, 1639GCT, N82W
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
10.0
1.0
.10
.01
.001
DISPLACEMENT-CM
1000
100
10.0
1.0

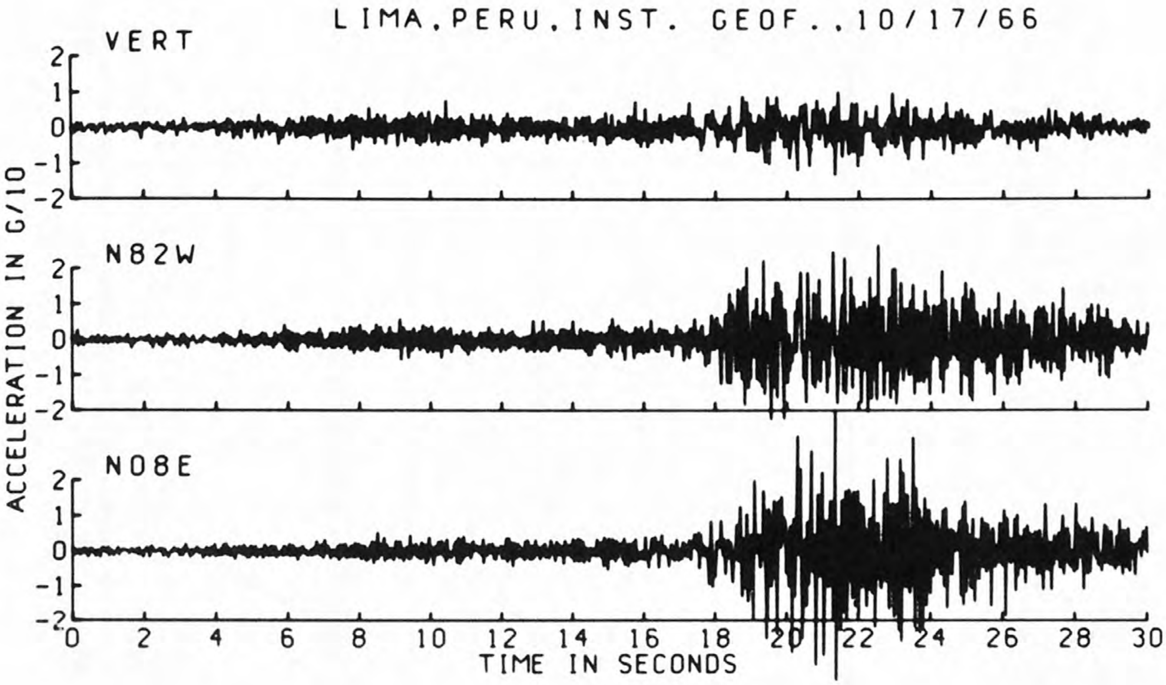

RESPONSE SPECTRA
LIMA,PERU,INST GEOF,1/31/51,1639GCT,N08E
0,2,5,10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
ACCELERATION-G
10.0
1.0
.10
.01
.001
DISPLACEMENT-CM
1000
100
10.0
1.0
.10
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS

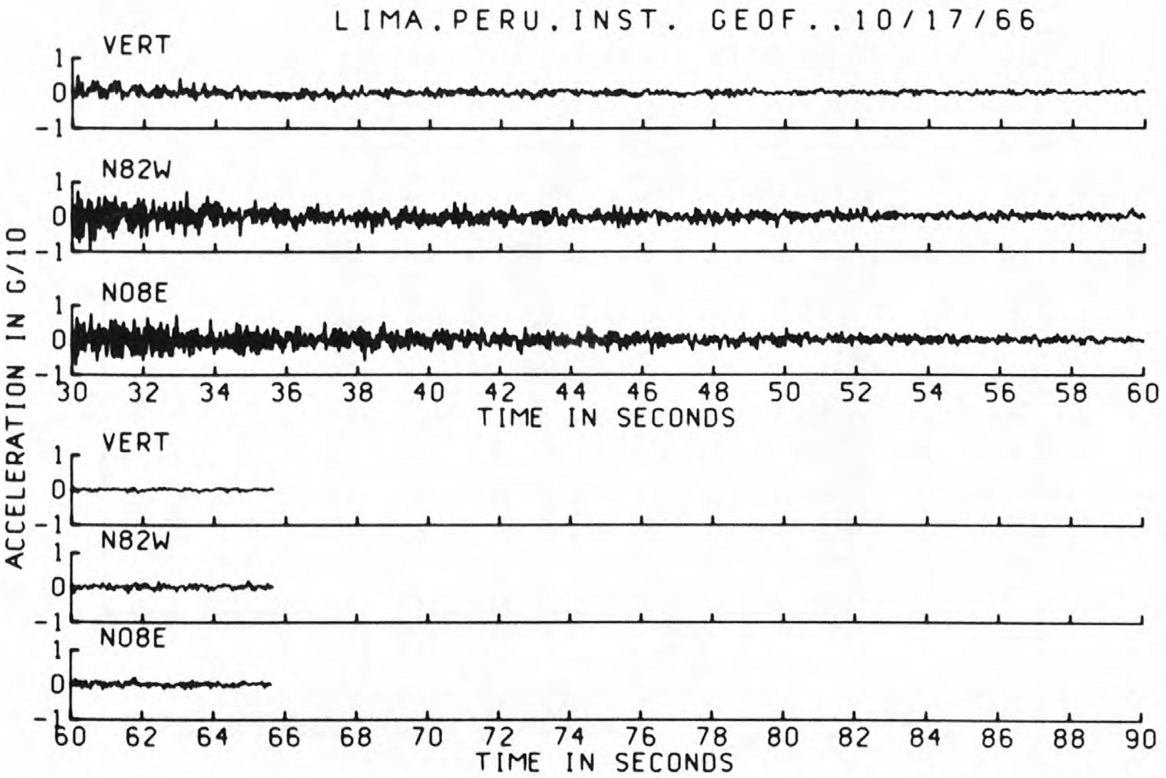

DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST GEOF, 1/31/51, 1639GCT, VERT
UNITS=CM/SEC
1.0+
1 CYCLE
2 CYCLES
4 CYCLES
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
0
1
2
3
4
0
2
4
6
8


DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST GEOF, 1/31/51, 1639GCT, N82W
UNITS=CM/SEC
1.0-2.0,
2.0+
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
0
1
2
3
4
0
2
4
6
8

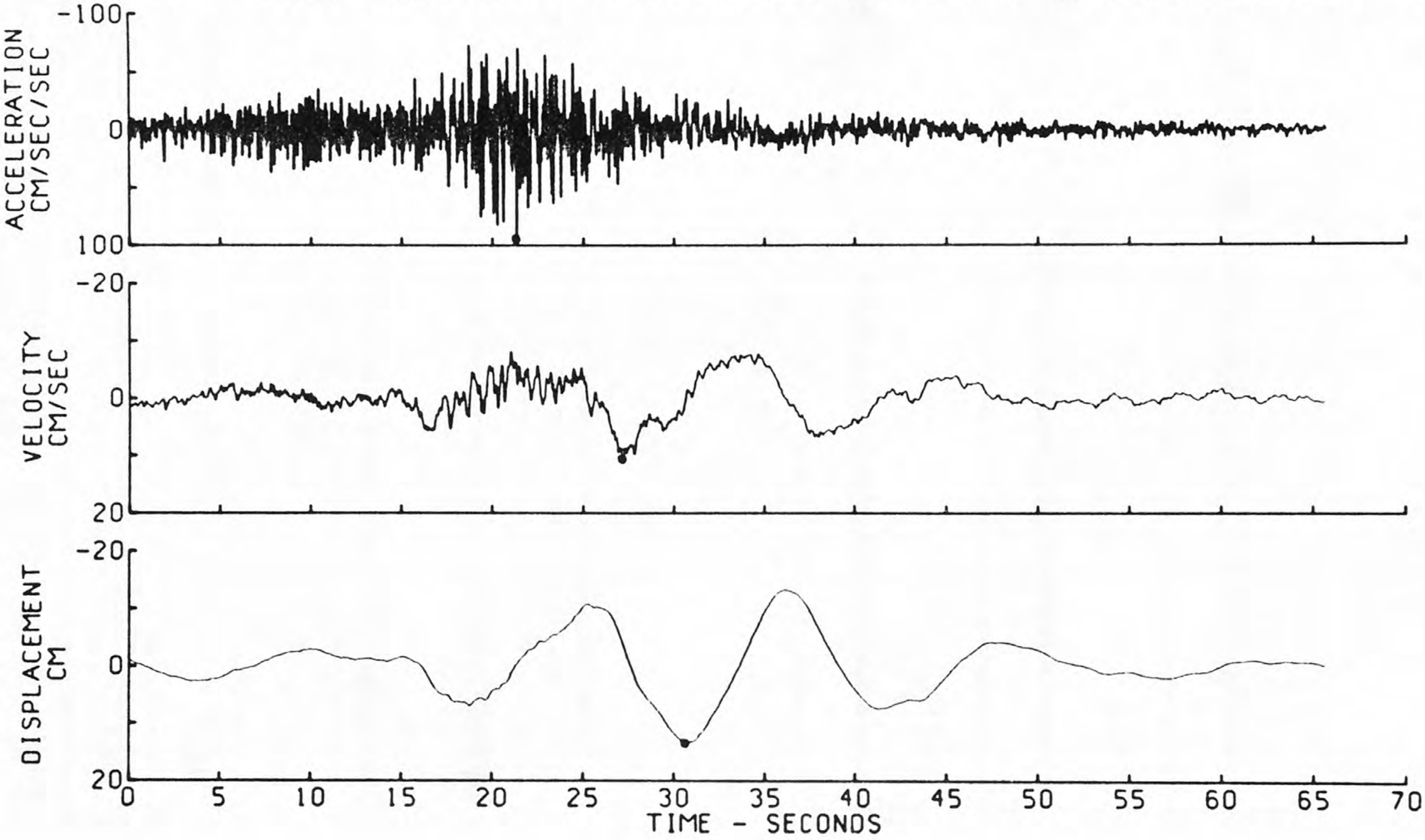
DURATION SPECTRUM OF THE VELOCITY RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST GEOF, 1/31/51, 1639GCT, N08E



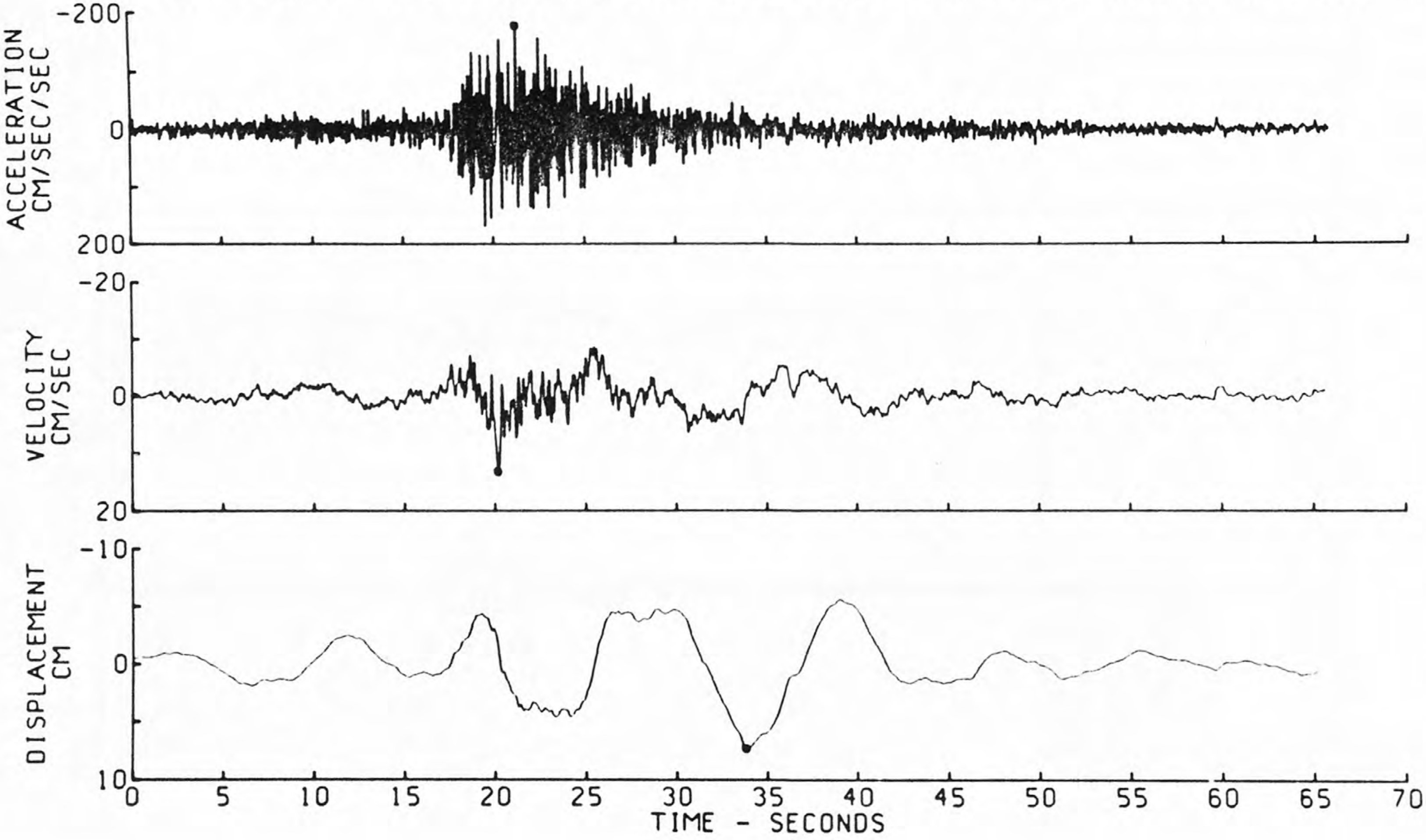

LIMA.PERU.INST. GEOF..10/17/66
VERT
N82W
N08E
ACCELERATION IN G/10
TIME IN SECONDS


LIMA.PERU.INST. GEOF..10/17/66
VERT
N82W
N08E
ACCELERATION IN G/10
TIME IN SECONDS

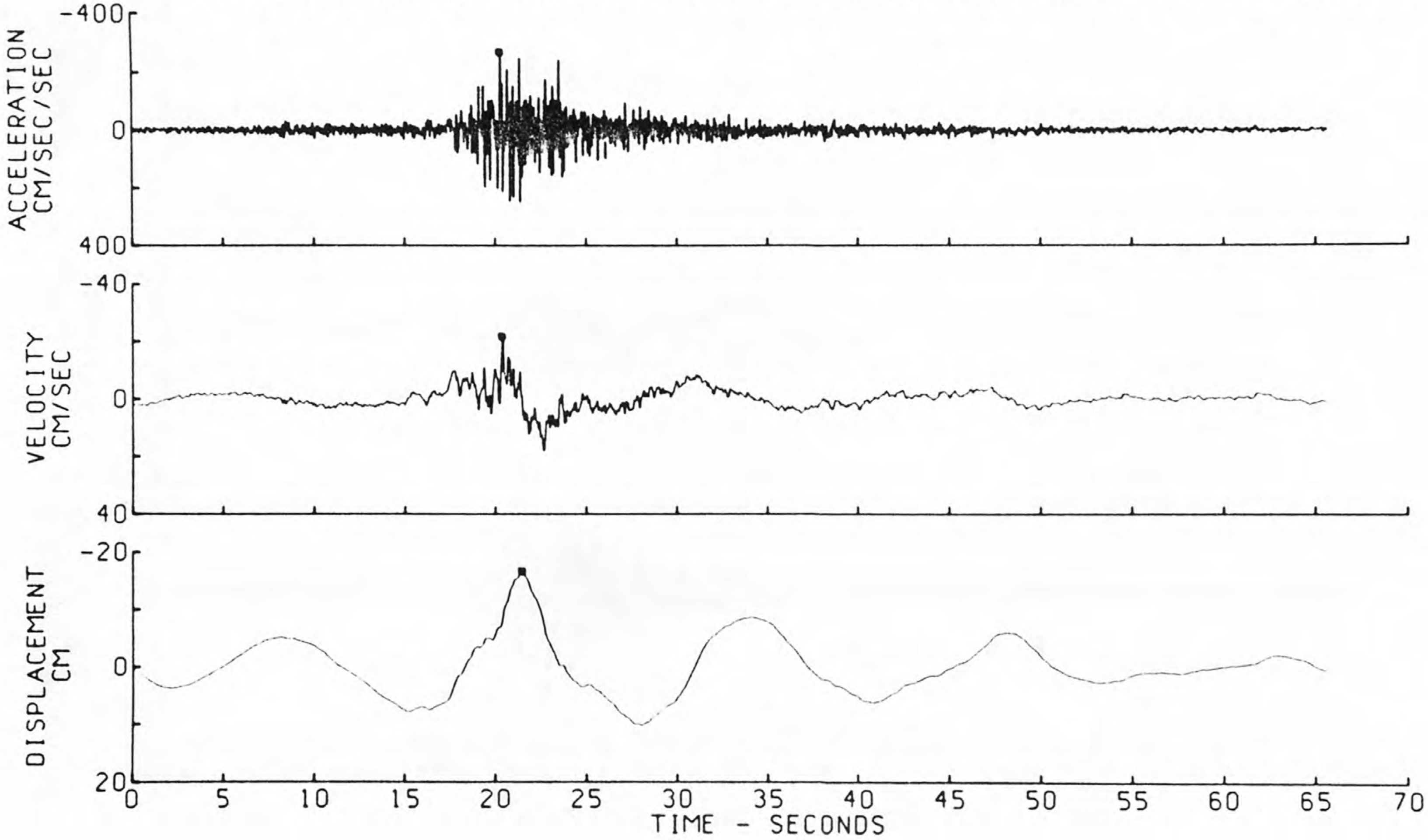
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF OCTOBER 10, 1966
INSTITUTO GEOFISICO DEL PERU, VERT COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .050 - .070 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=94.25 CM/SEC/SEC, VELOCITY=10.61 CM/SEC, DISPL=13.50 CM

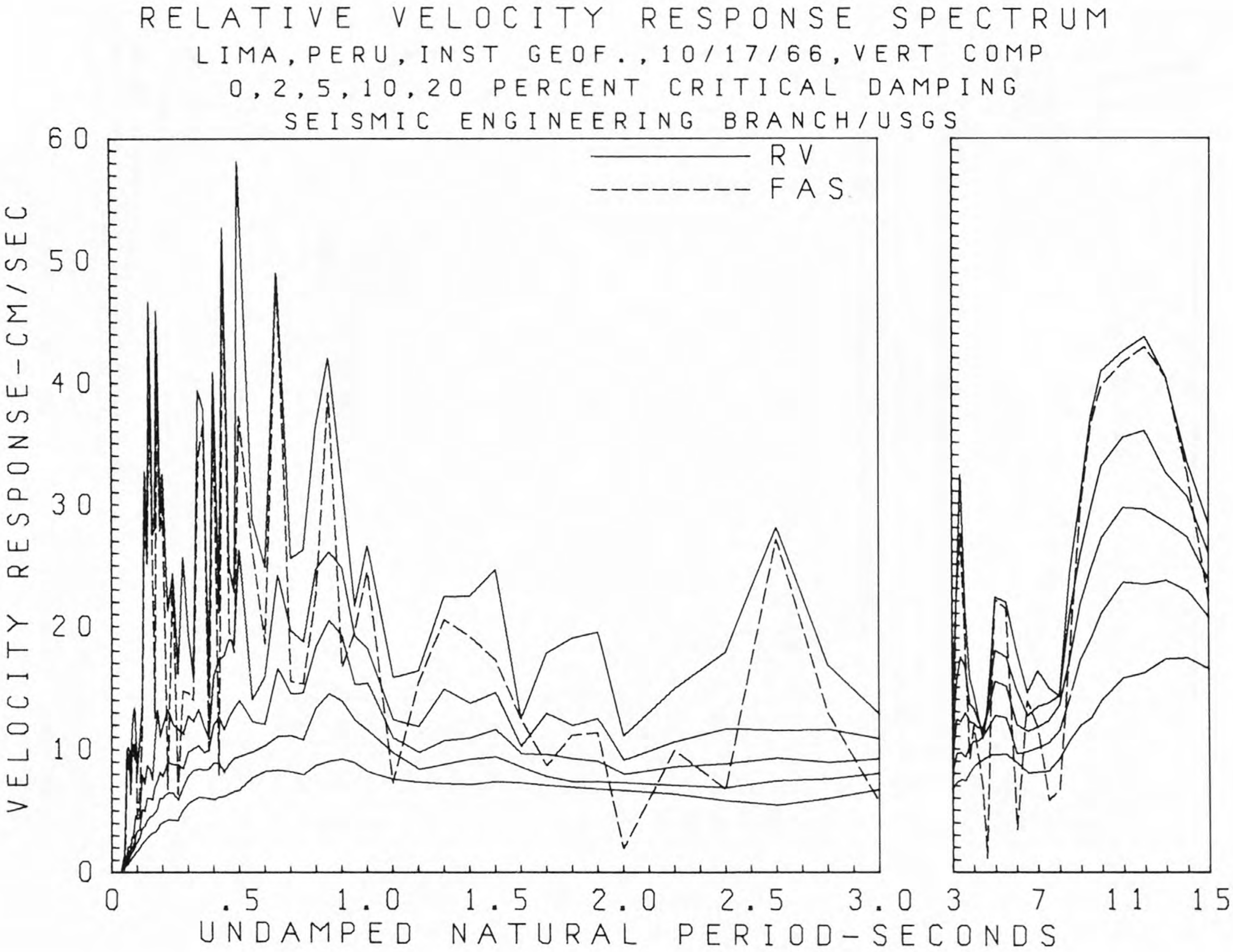


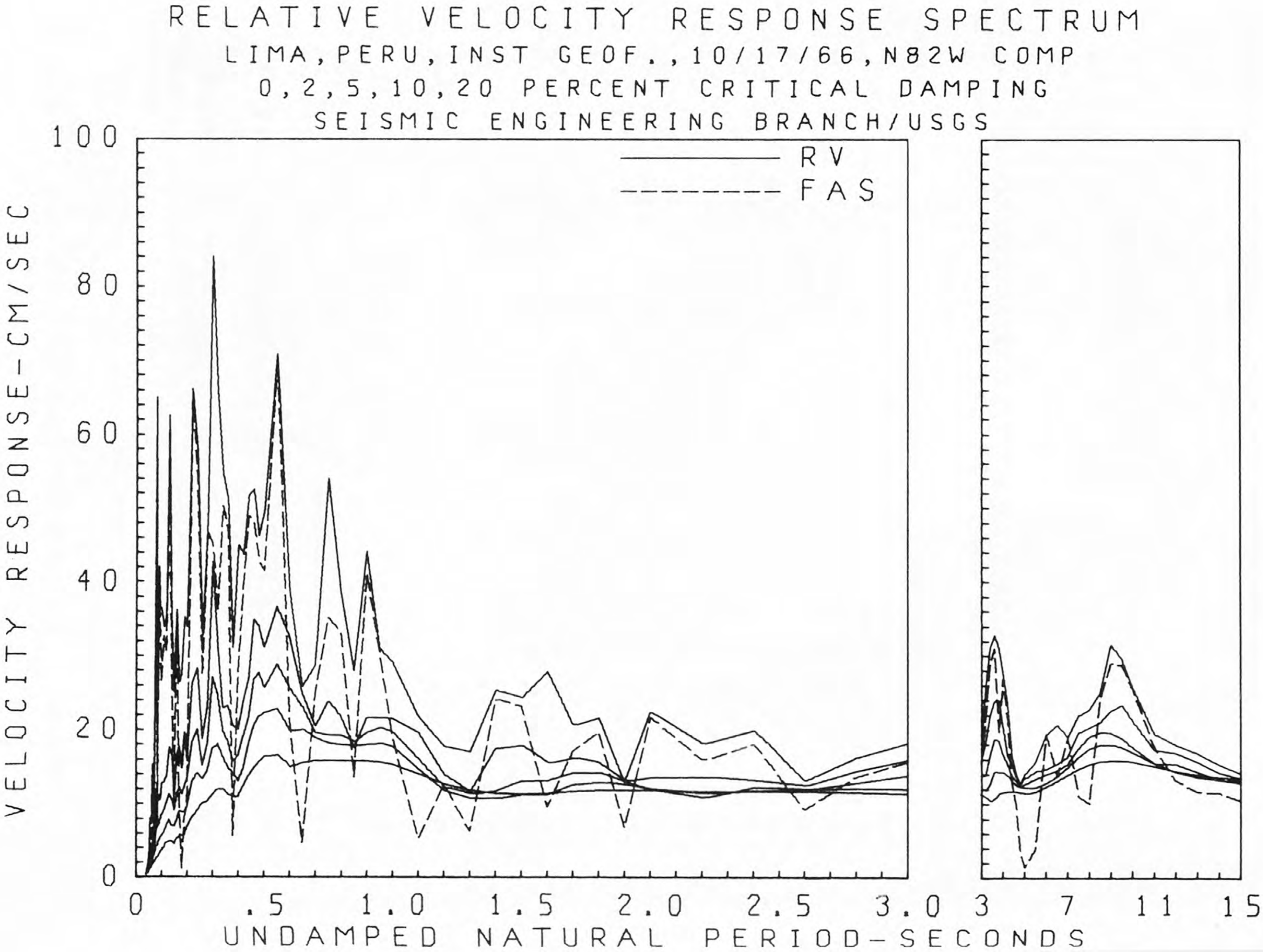
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF OCTOBER 10, 1966
INSTITUTO GEOFISICO DEL PERU, N82W COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .050 - .070 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-180.6 CM/SEC/SEC, VELOCITY=13.23 CM/SEC, DISPL=7.350 CM

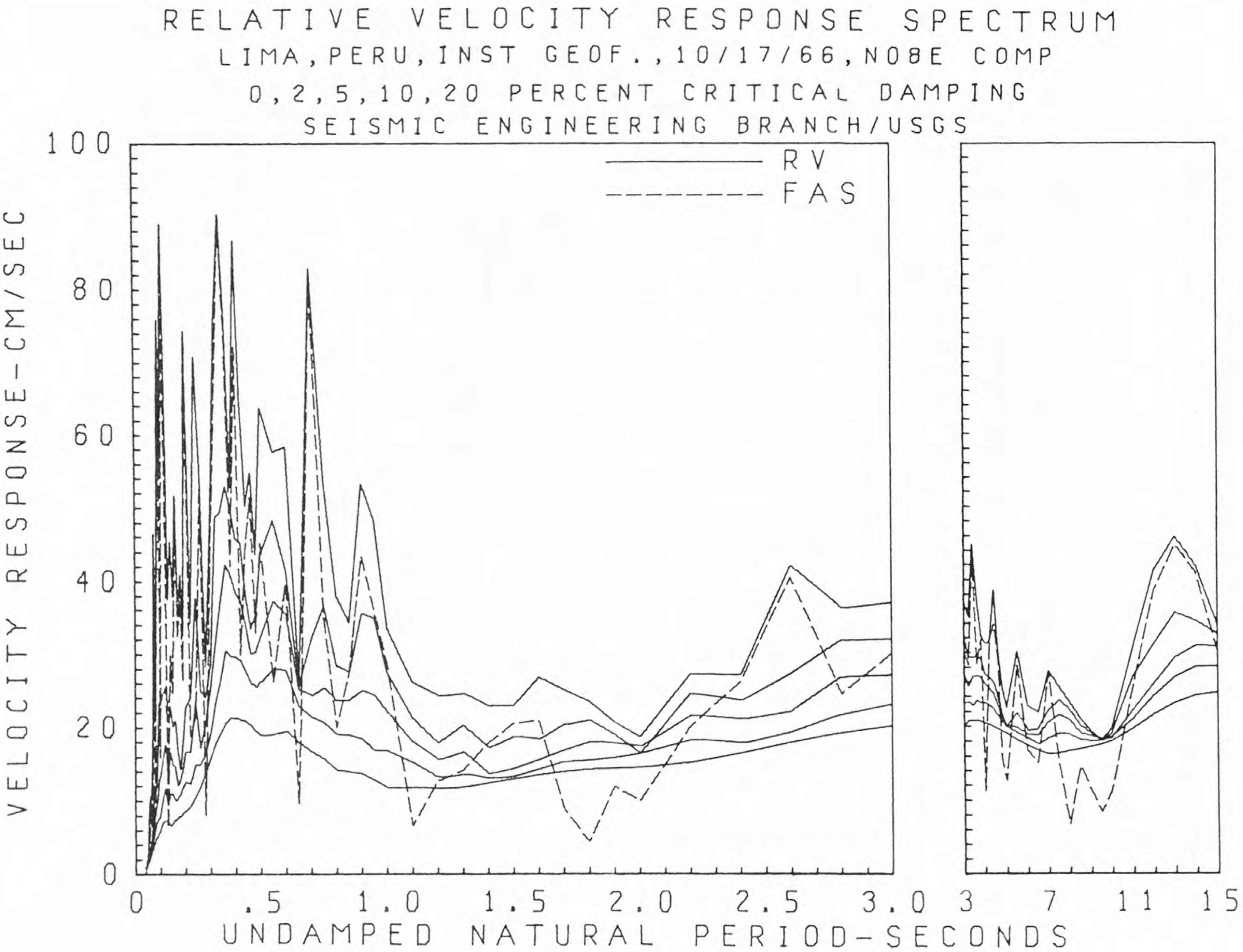


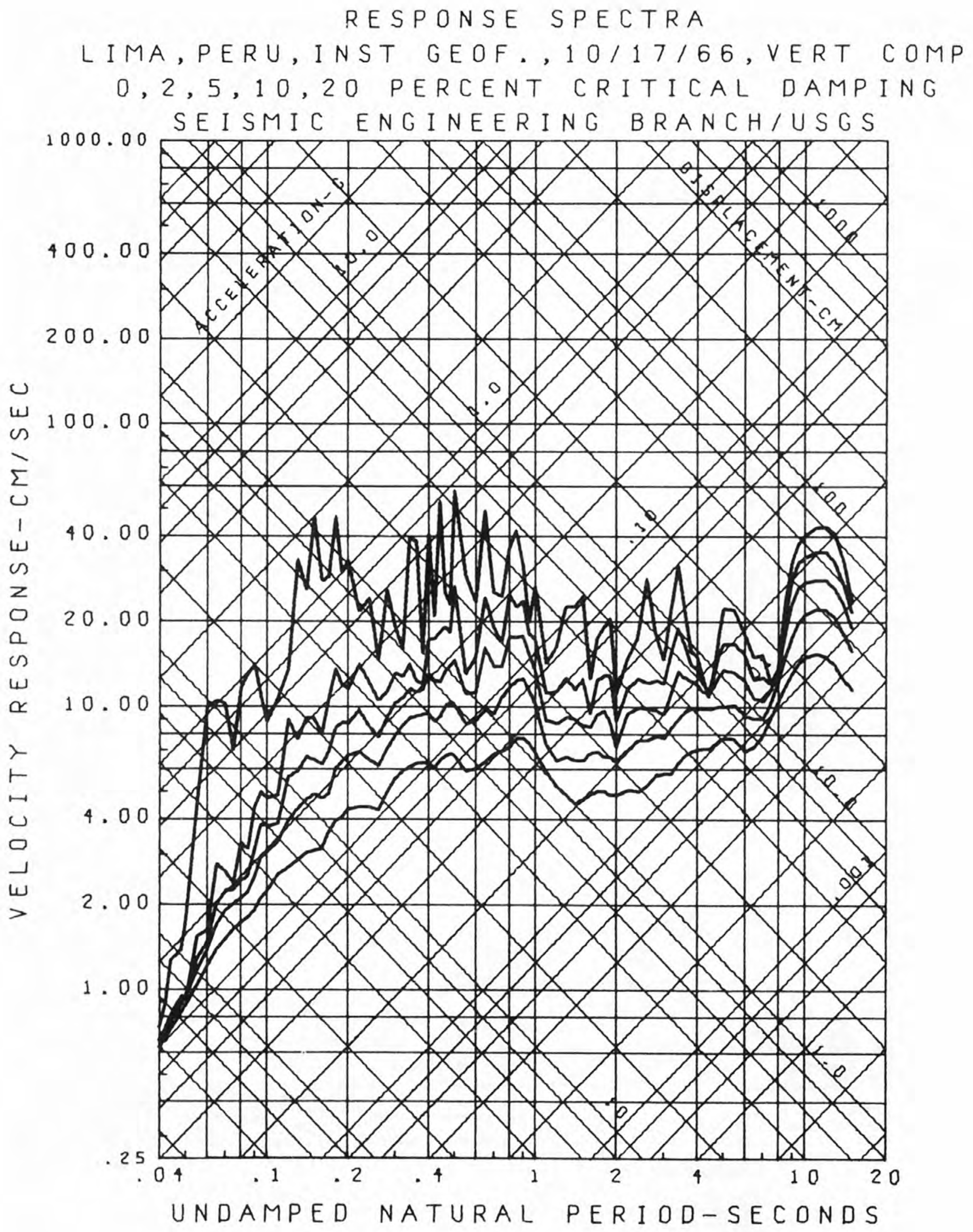
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF OCTOBER 10, 1966
INSTITUTO GEOFISICO DEL PERU, N08E COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .050 - .070 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-269.3 CM/SEC/SEC, VELOCITY=-21.60 CM/SEC, DISPL=-16.60 CM

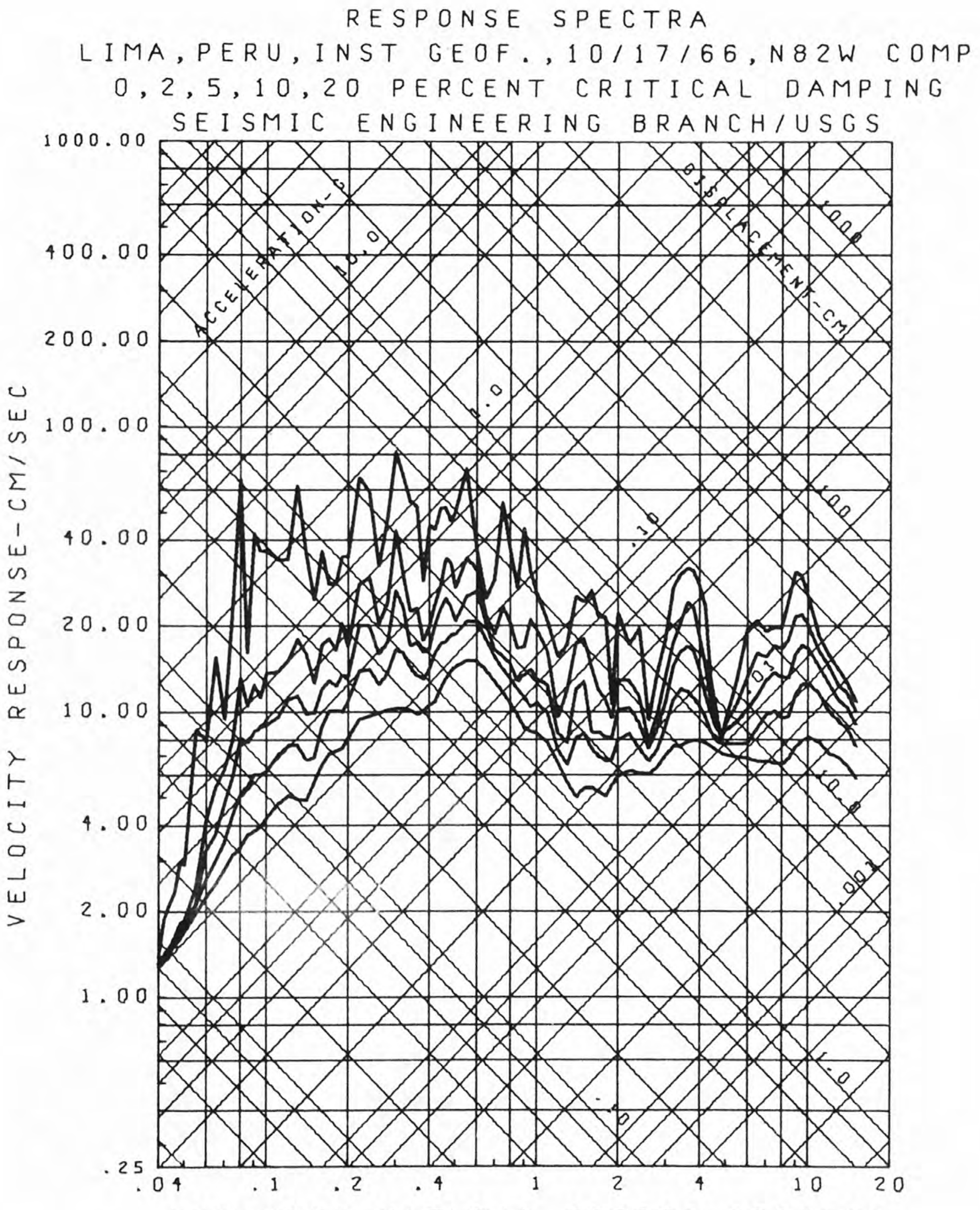



RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST GEOF., 10/17/66, VERT COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
0
10
20
30
40
50
60
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

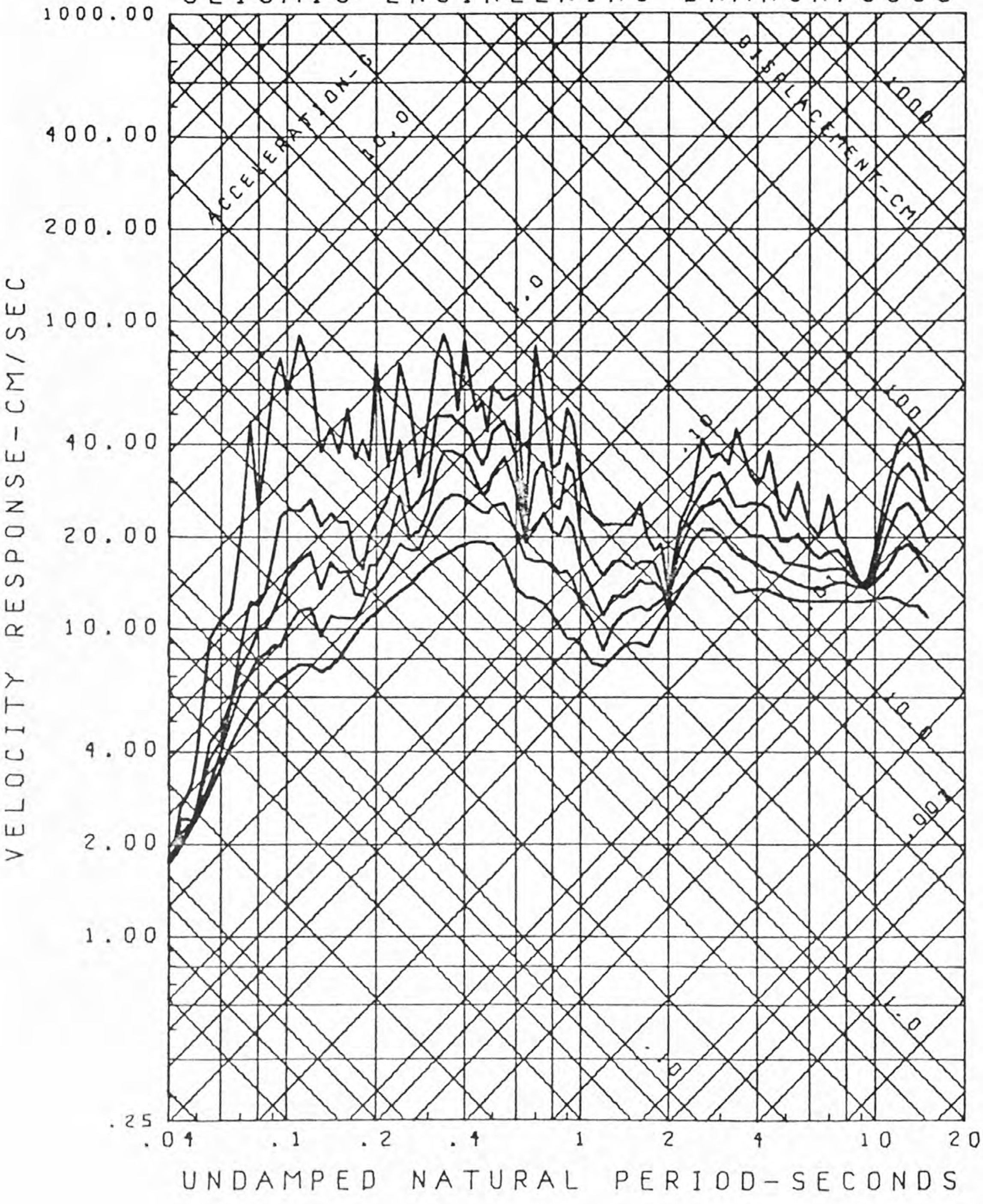

RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST GEOF., 10/17/66, N82W COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
100
80
60
40
20
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

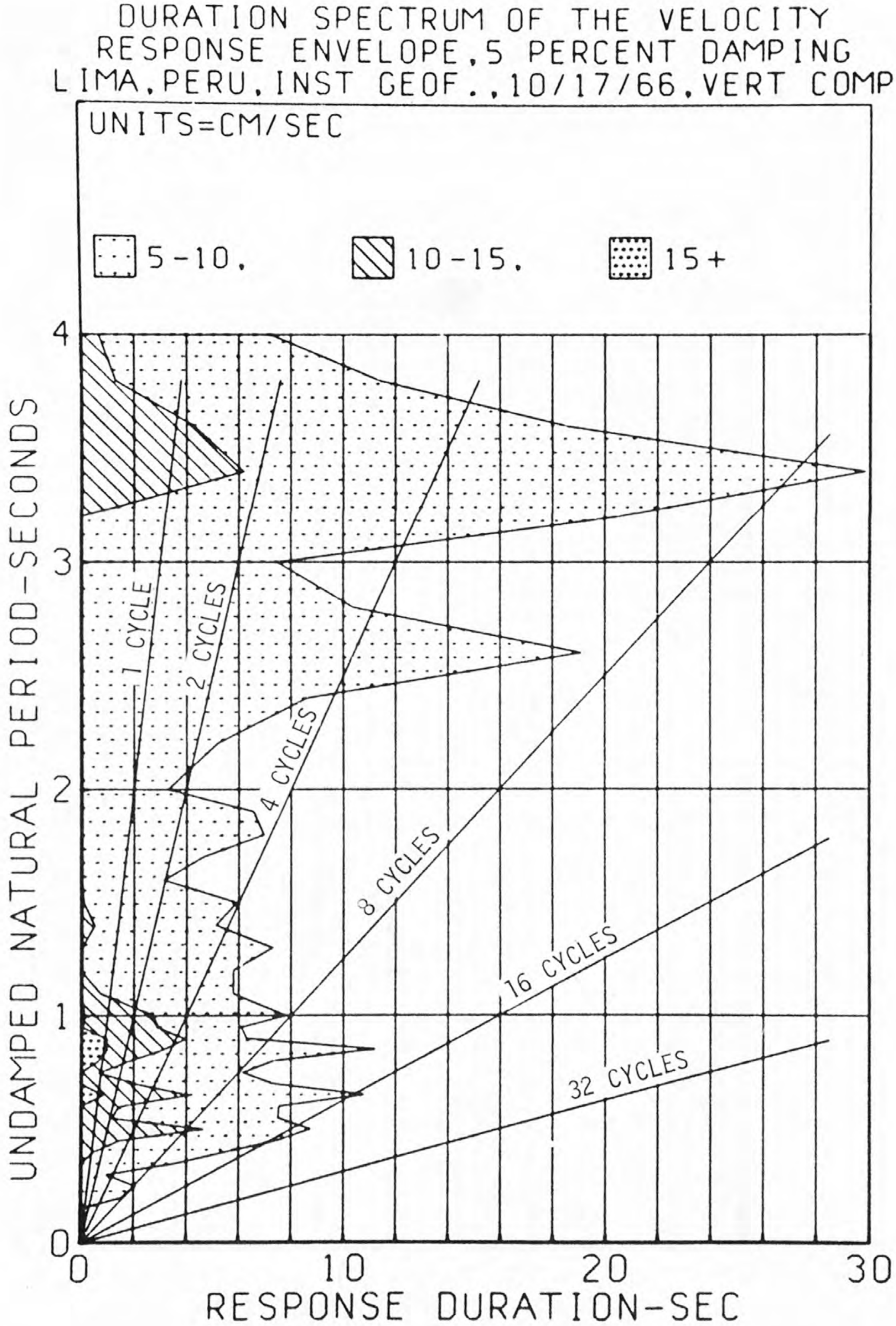

RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST GEOF., 10/17/66, N08E COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
0
20
40
60
80
100
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

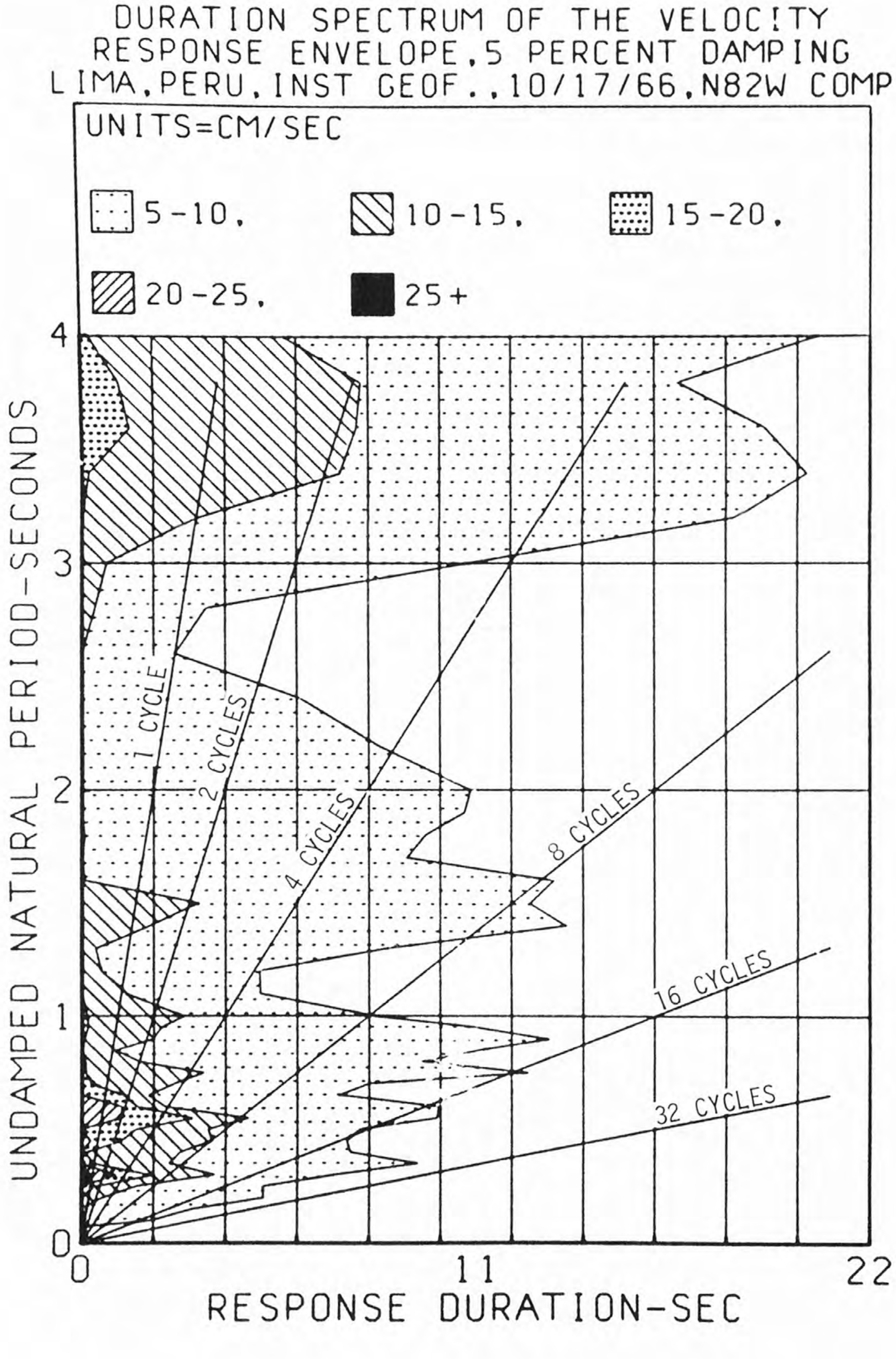

RESPONSE SPECTRA
LIMA,PERU,INST GEOF.,10/17/66,VERT COMP
0,2,5,10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
.04
.1
.2
.4
1
2
4
10
20
ACCELERATION-G
DISPLACEMENT-CM


RESPONSE SPECTRA
LIMA, PERU, INST GEOF., 10/17/66, N82W COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
ACCELERATION-G
DISPLACEMENT-CM
UNDAMPED NATURAL PERIOD-SECONDS
.04
.1
.2
.4
1
2
4
10
20

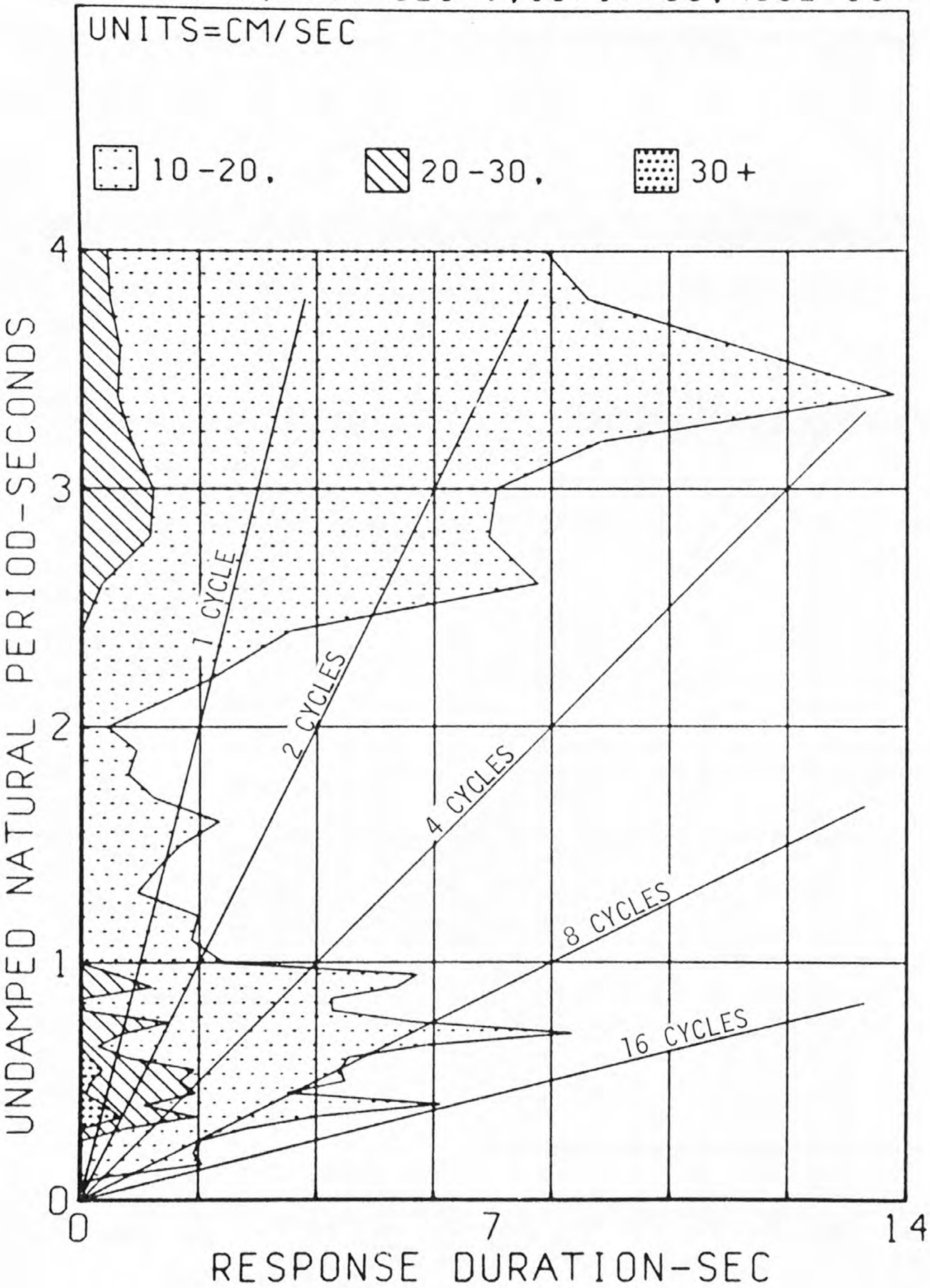
RESPONSE SPECTRA
LIMA, PERU, INST GEOF., 10/17/66, N08E COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

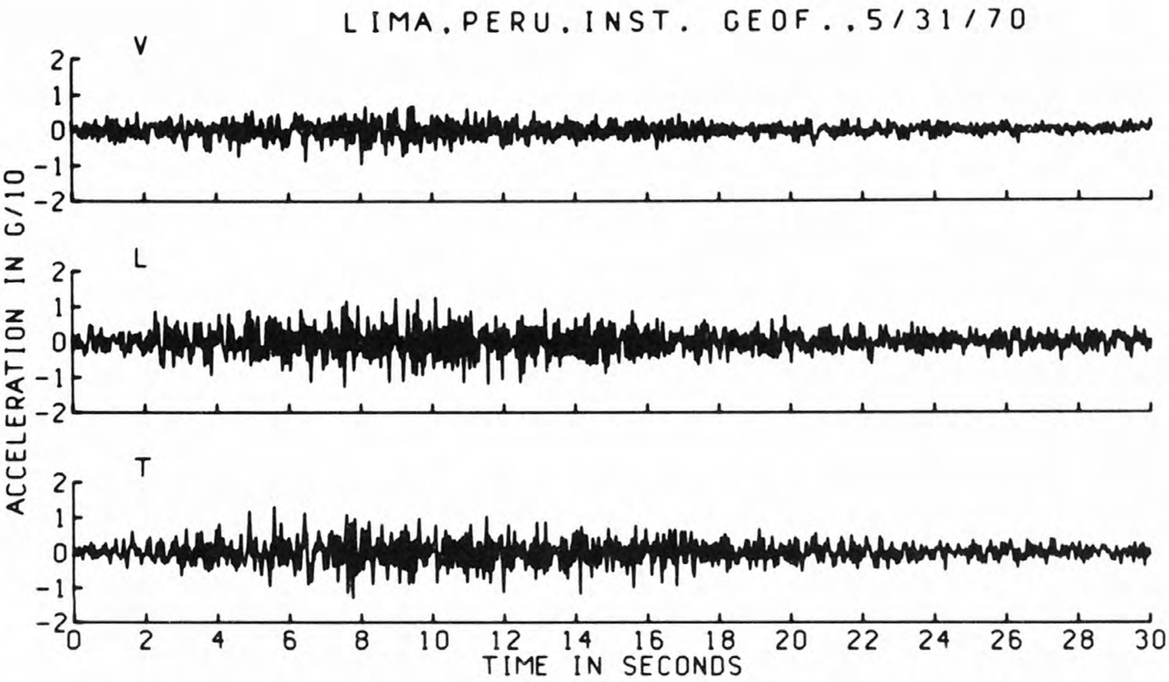


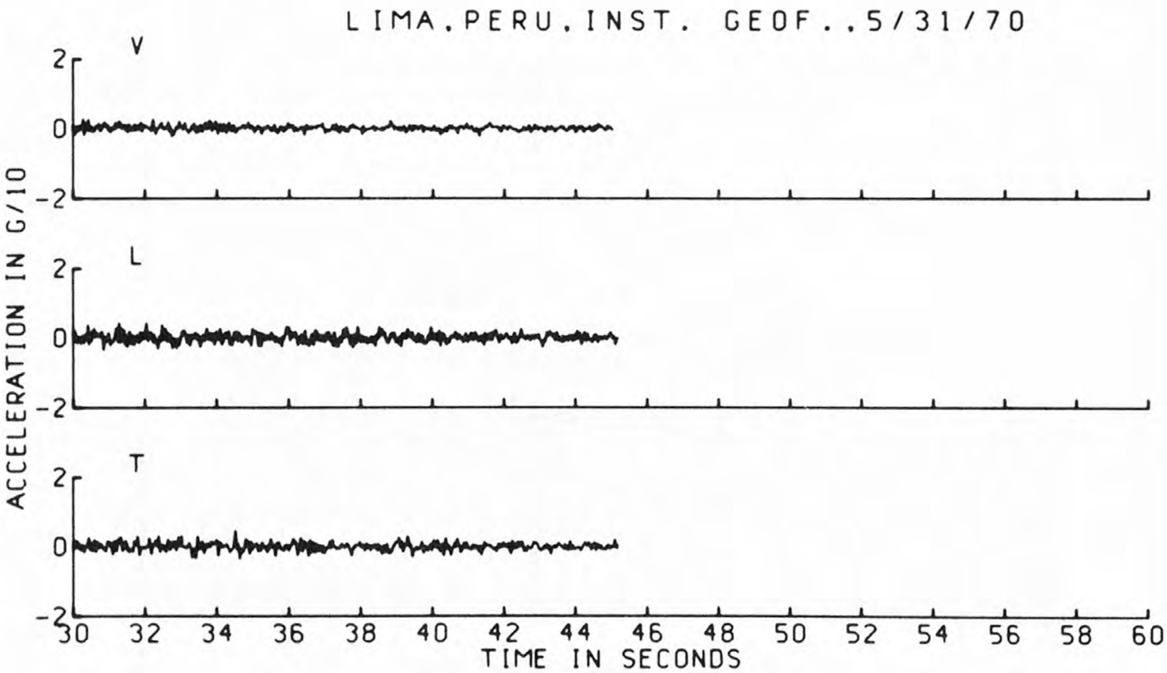

DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST GEOF., 10/17/66, VERT COMP
UNITS=CM/SEC
5-10.
10-15.
15+
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
0
1
2
3
4
0
10
20
30


DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST GEOF., 10/17/66, N82W COMP
UNITS=CM/SEC
5-10.
10-15.
15-20.
20-25.
25+
UNDAMPED NATURAL PERIOD-SECONDS
0
1
2
3
4
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
0
11
22
RESPONSE DURATION-SEC

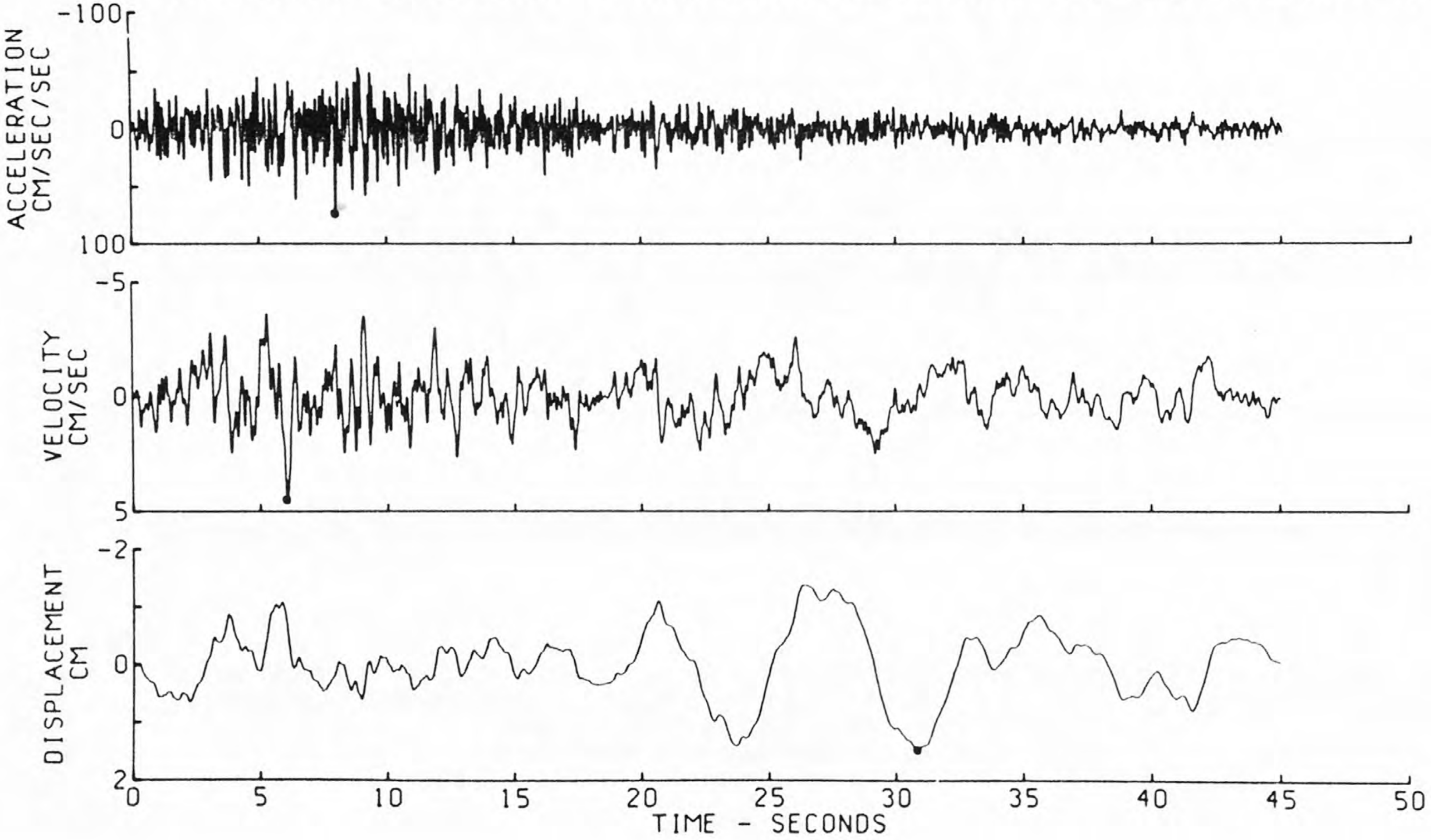
DURATION SPECTRUM OF THE VELOCITY RESPONSE ENVELOPE, 5 PERCENT DAMPING LIMA, PERU, INST GEOF., 10/17/66, N08E COMP



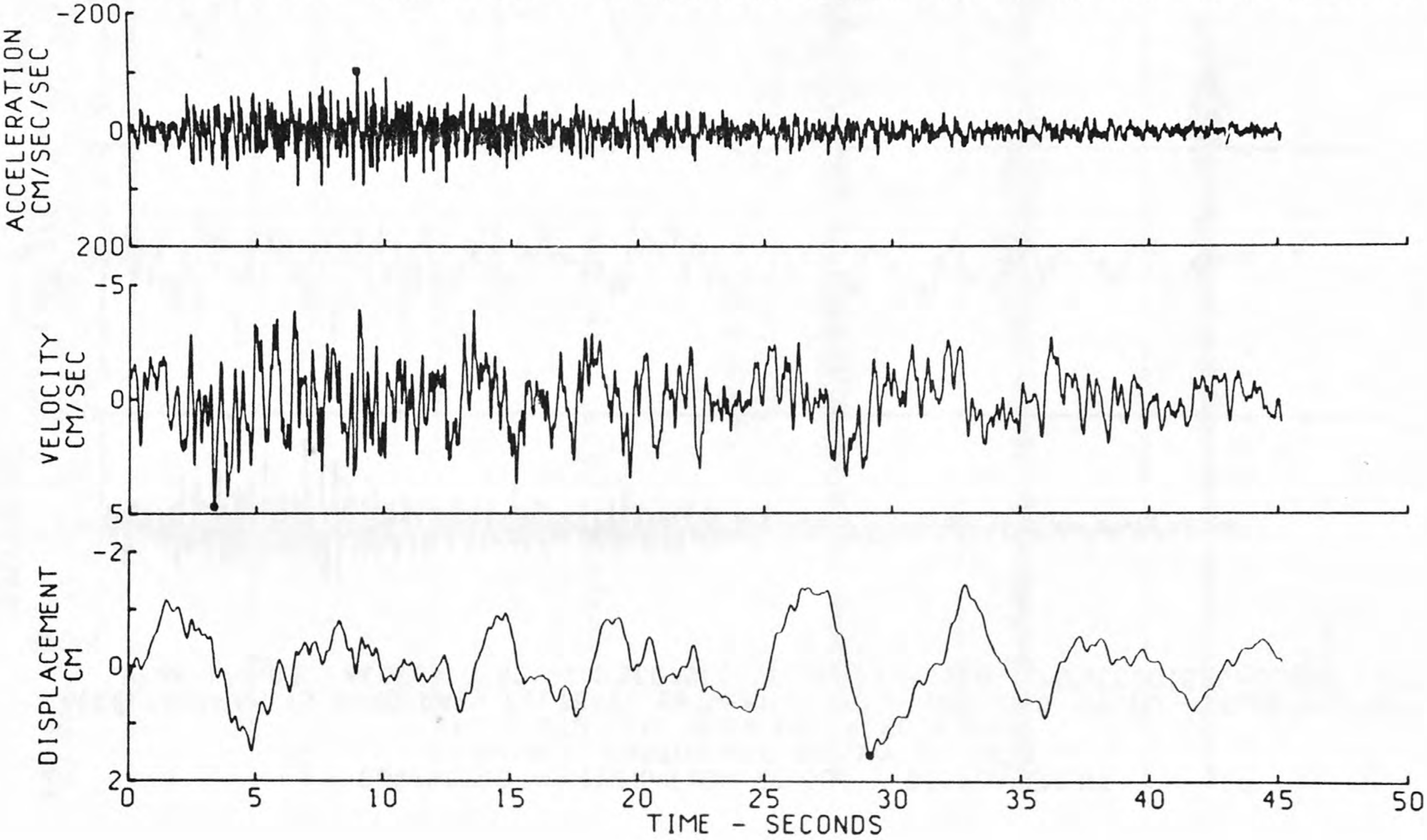

LIMA, PERU, INST. GEOF., 5/31/70
V
L
T
ACCELERATION IN G/10
2
1
0
-1
-2
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
TIME IN SECONDS


LIMA, PERU, INST. GEOF., 5/31/70
V
L
T
ACCELERATION IN G/10
2
0
-2
30
32
34
36
38
40
42
44
46
48
50
52
54
56
58
60
TIME IN SECONDS

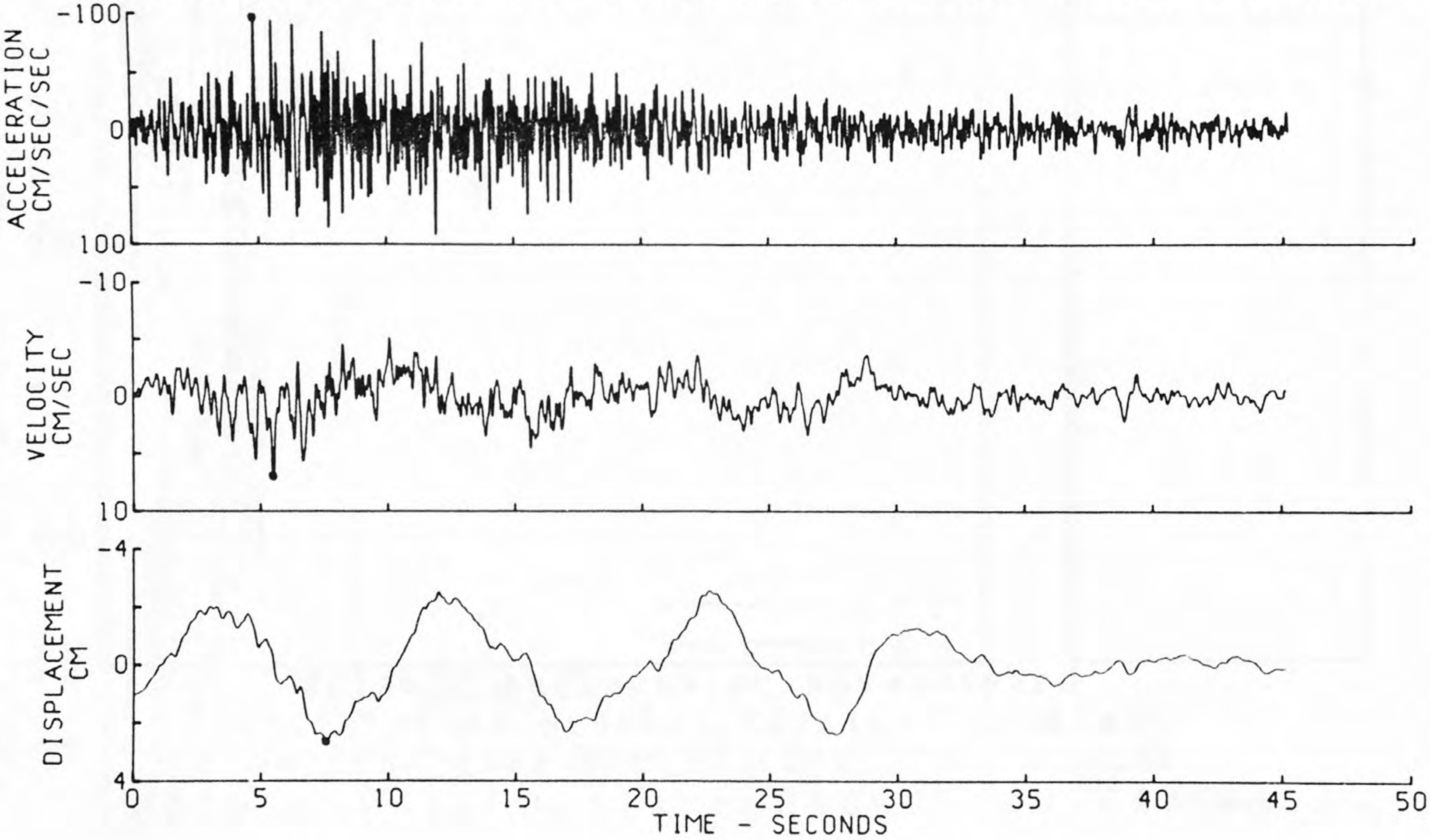
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF MAY 31, 1970
INSTITUTO GEOFISICO DEL PERU, V COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .070 - .100 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=73.52 CM/SEC/SEC, VELOCITY=4.510 CM/SEC, DISPL=1.480 CM



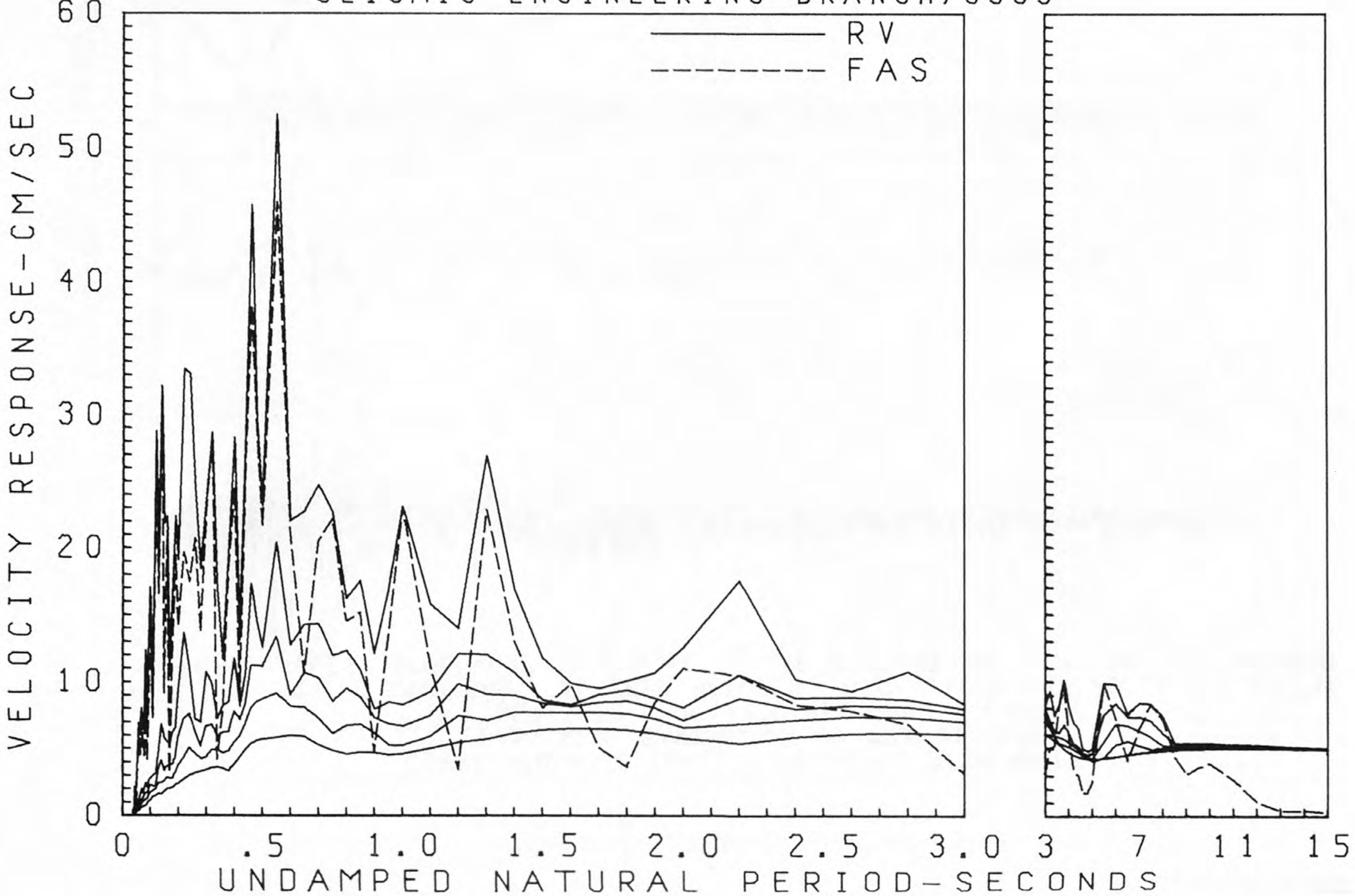
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF MAY 31, 1970
INSTITUTO GEOFISICO DEL PERU, L COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .070 - .100 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-104.8 CM/SEC/SEC, VELOCITY=4.710 CM/SEC, DISPL=1.550 CM

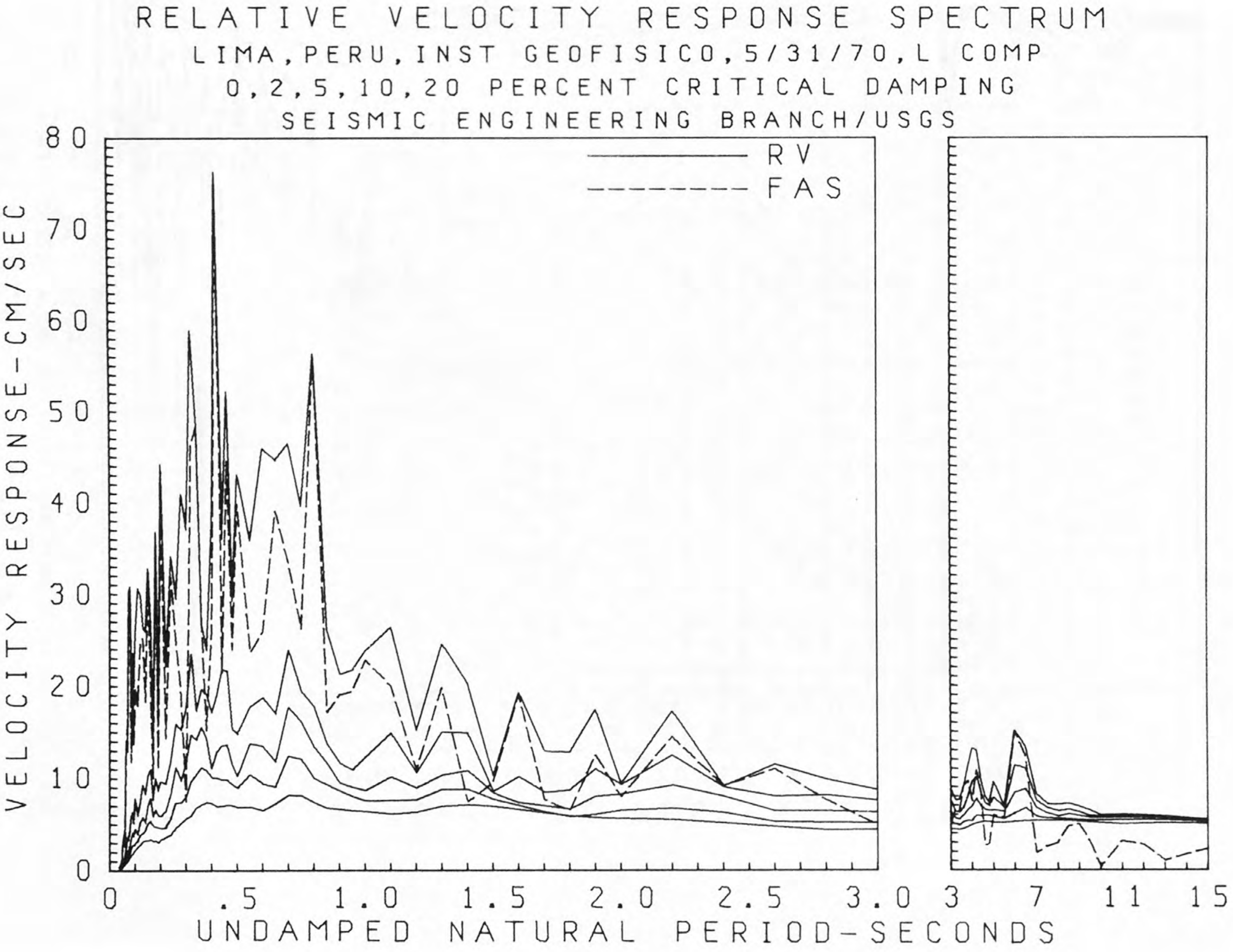


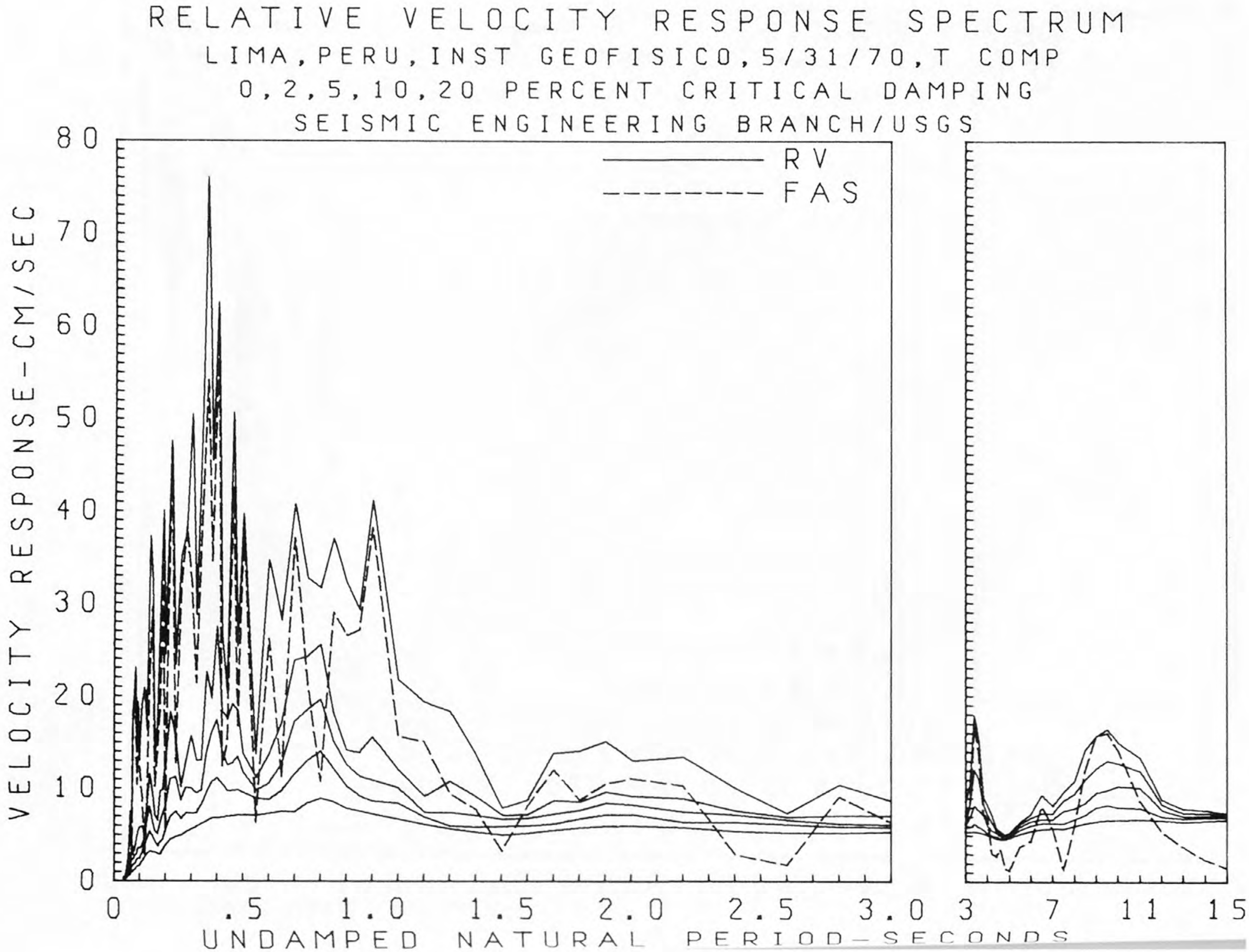
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF MAY 31, 1970
INSTITUTO GEOFISICO DEL PERU, T COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .070 - .100 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-97.75 CM/SEC/SEC, VELOCITY=6.980 CM/SEC, DISPL=2.640 CM

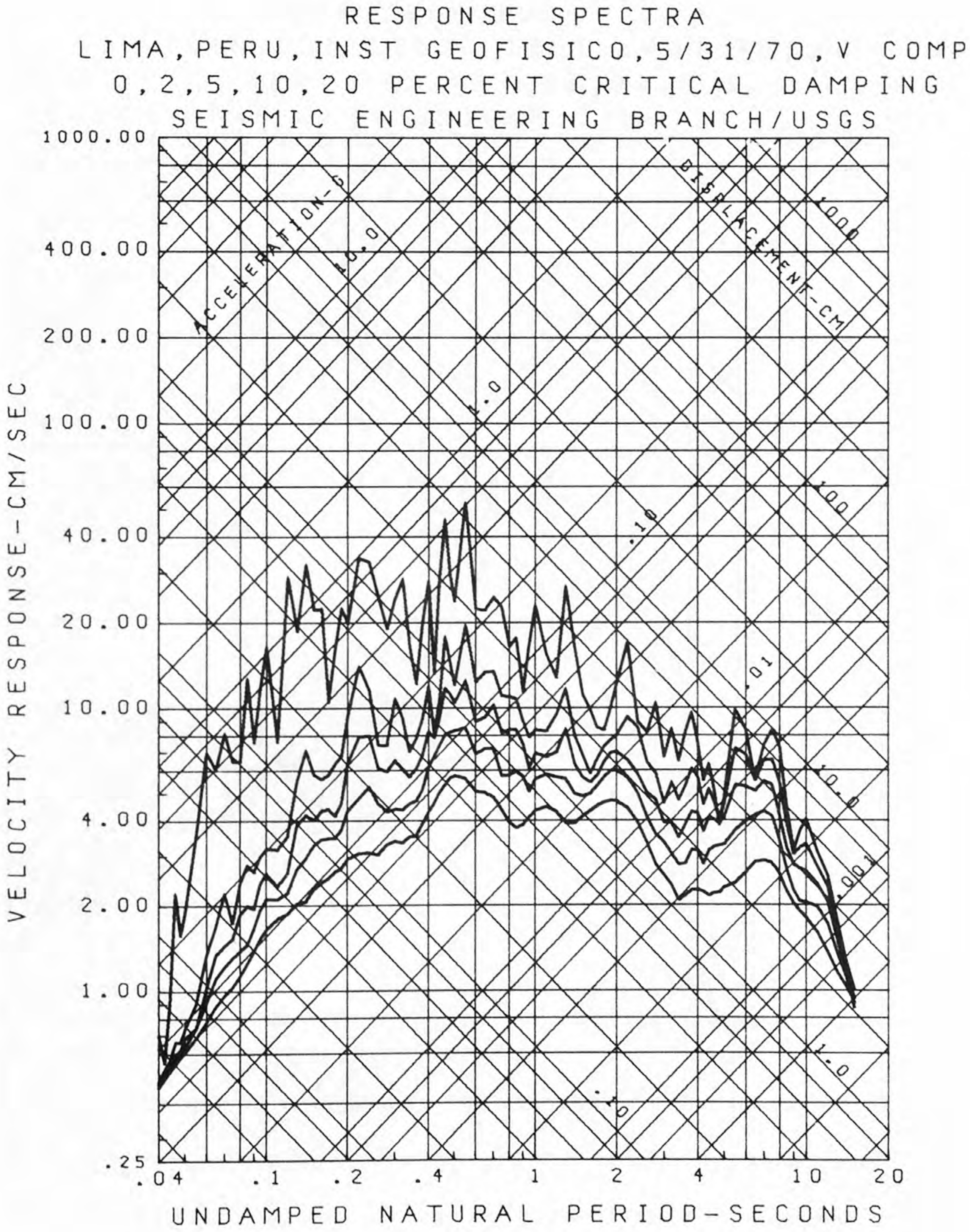


RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST GEOFISICO, 5/31/70, V COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

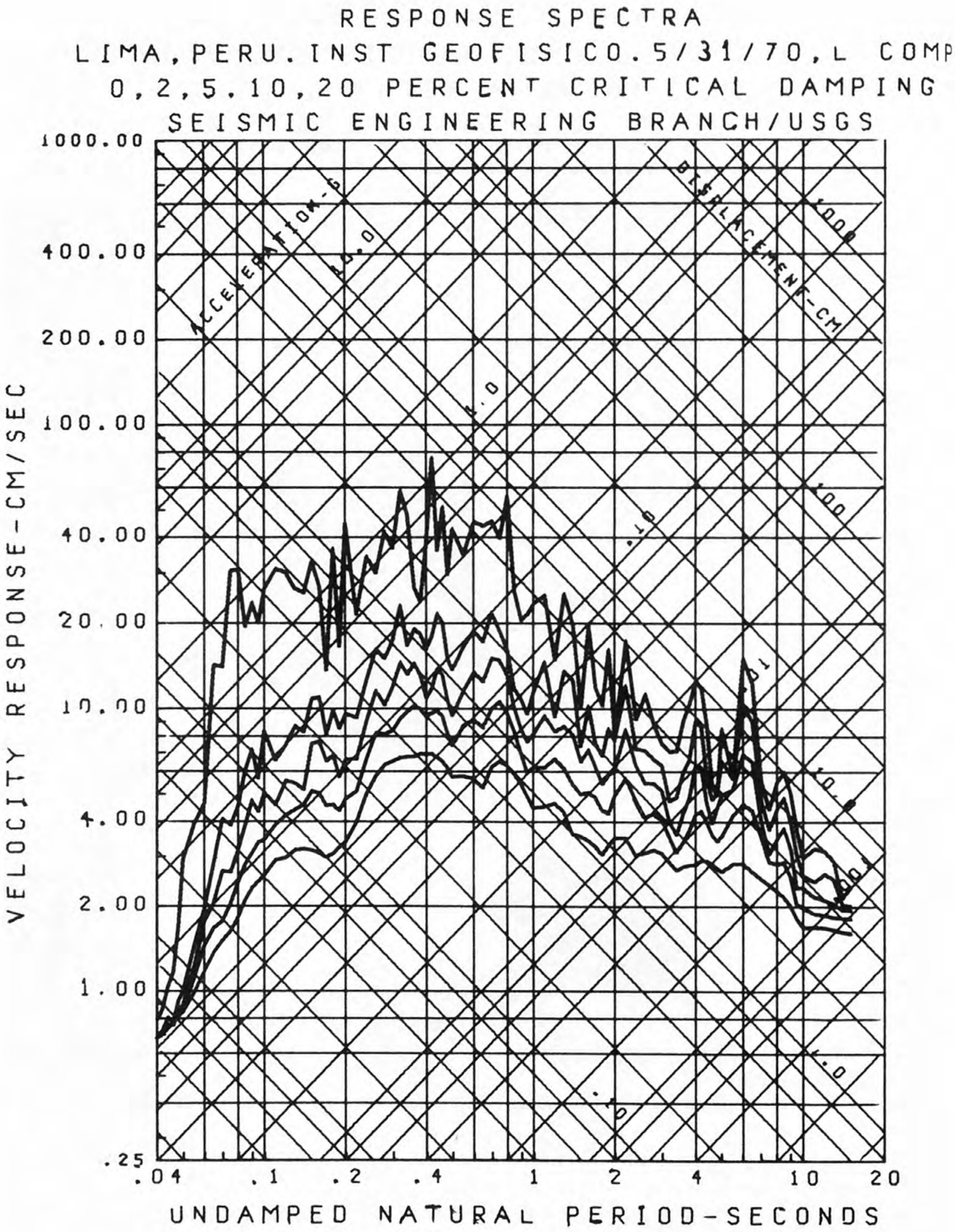


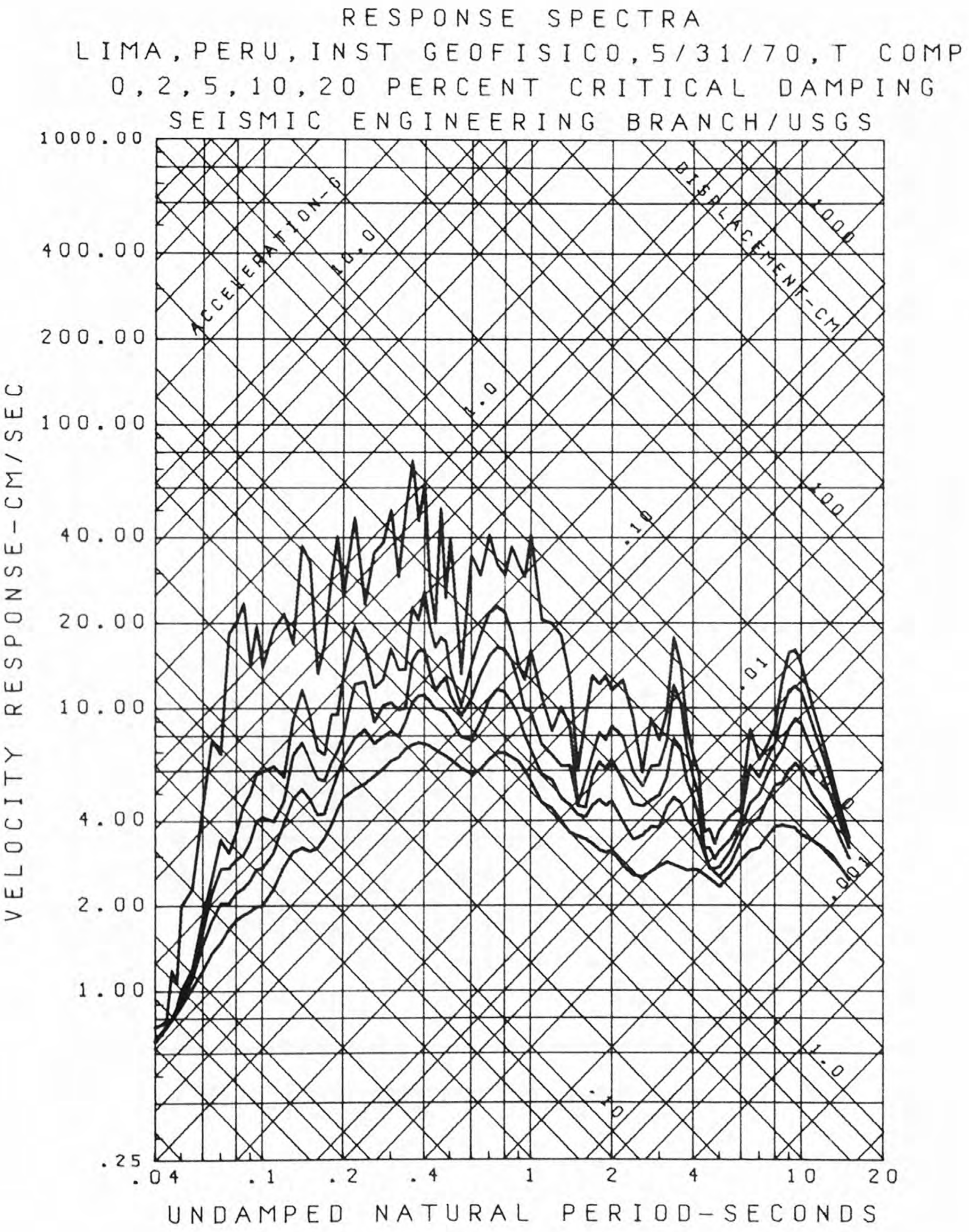

RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST GEOFISICO, 5/31/70, L COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
0
10
20
30
40
50
60
70
80
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

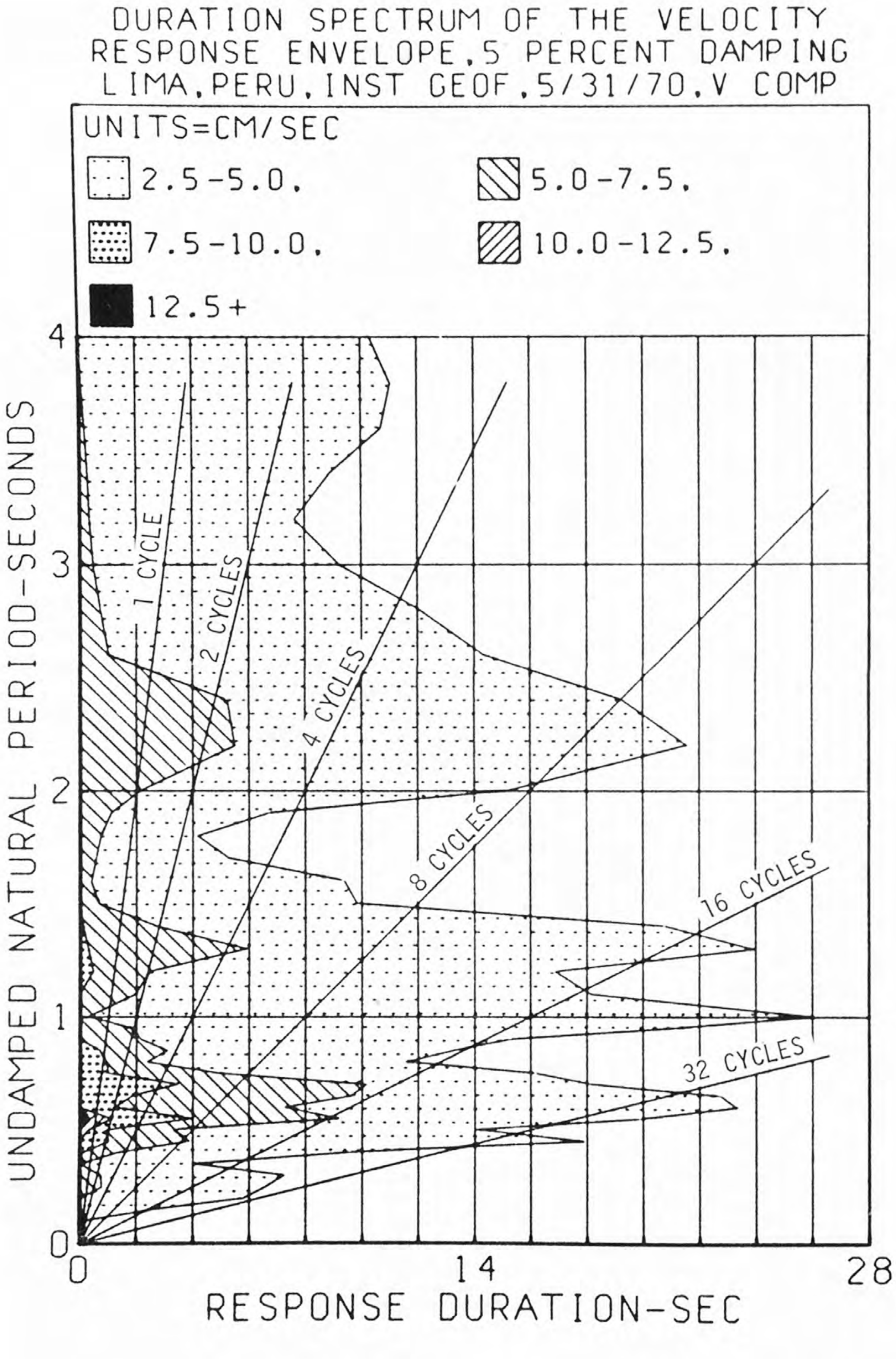

RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST GEOFISICO, 5/31/70, T COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
0
10
20
30
40
50
60
70
80
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

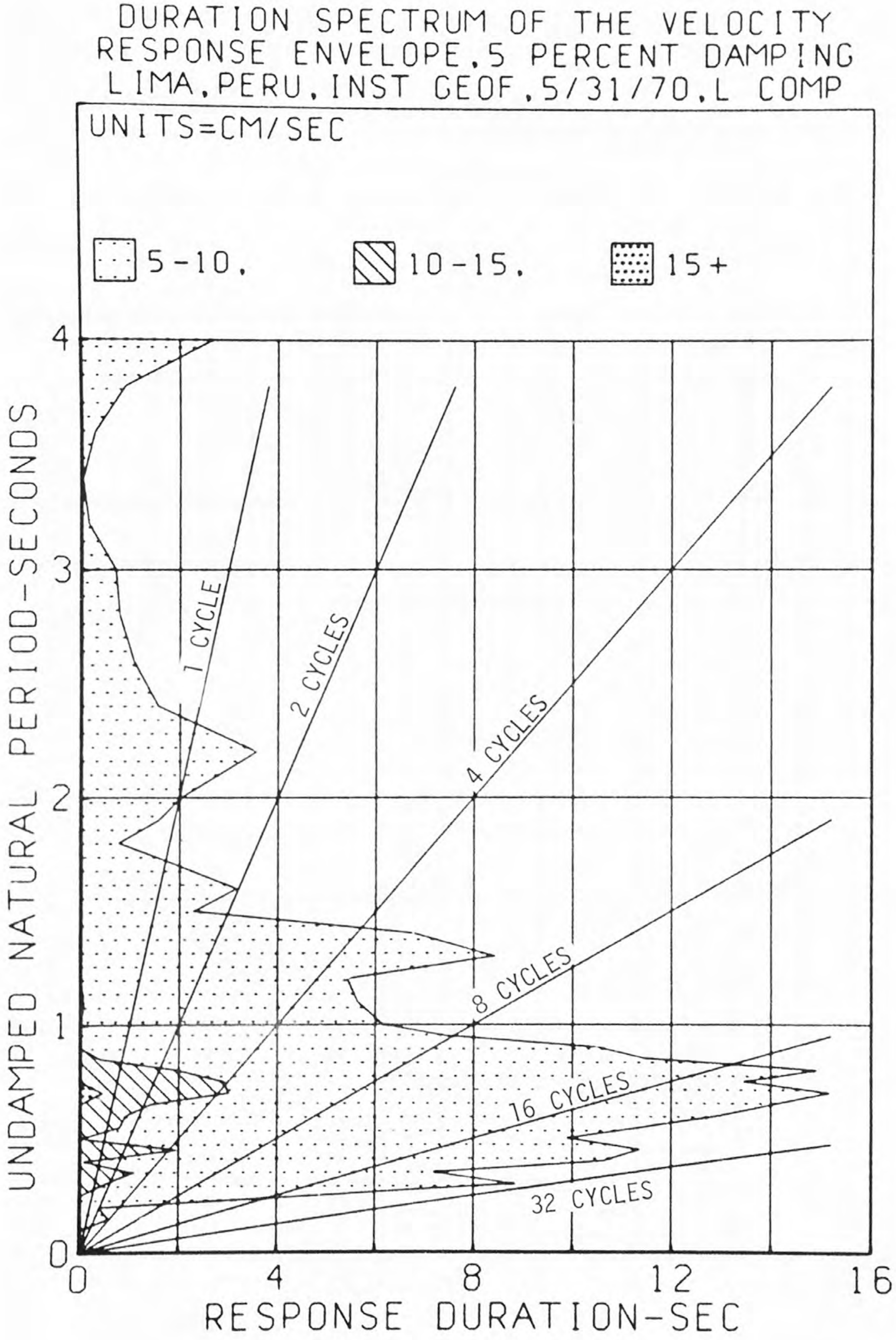


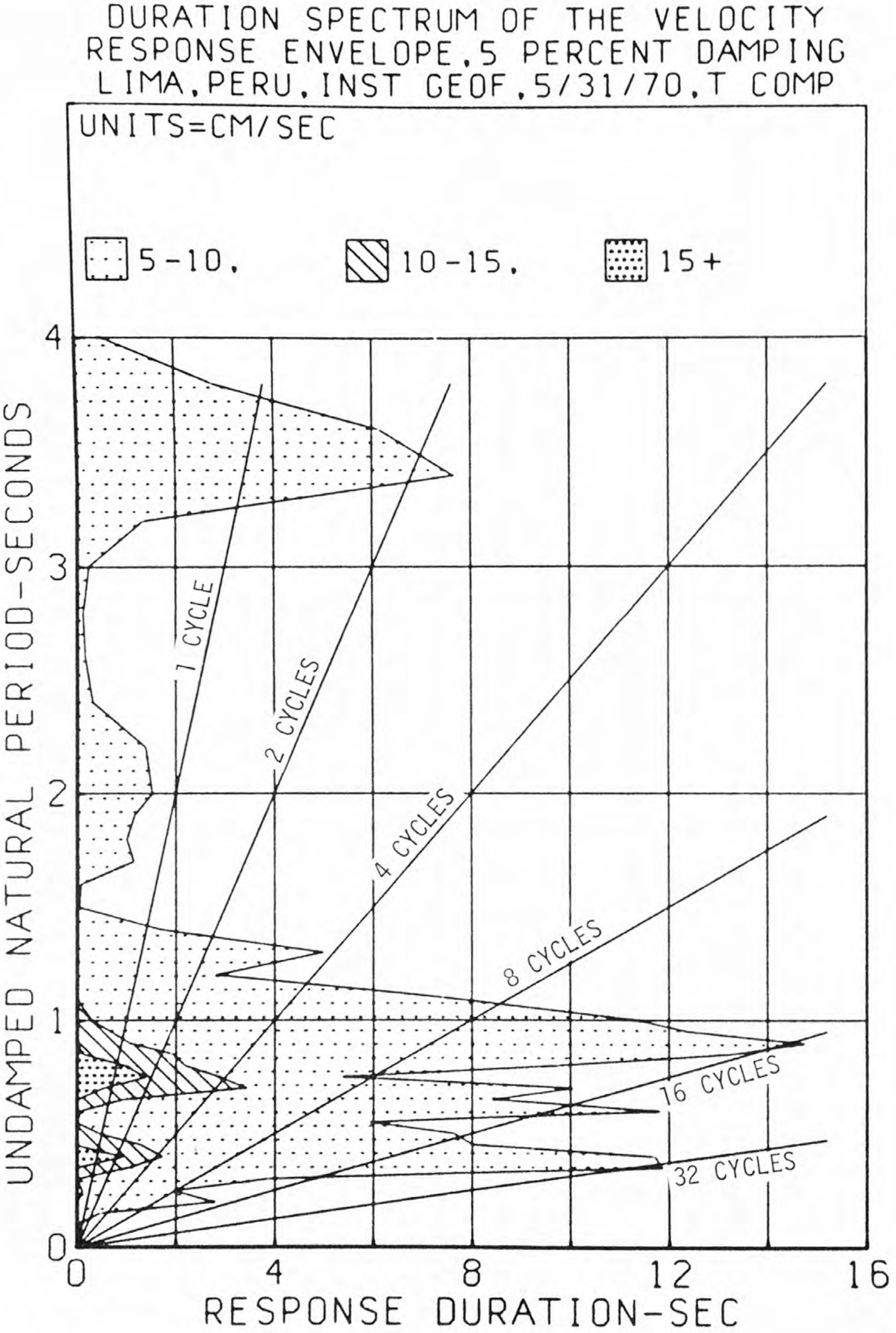
RESPONSE SPECTRA
LIMA,PERU,INST GEOFISICO,5/31/70,V COMP
0,2,5,10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
10.0
1.0
.10
.01
.001
DISPLACEMENT-CM
1000
100
10.0
1.0
.10

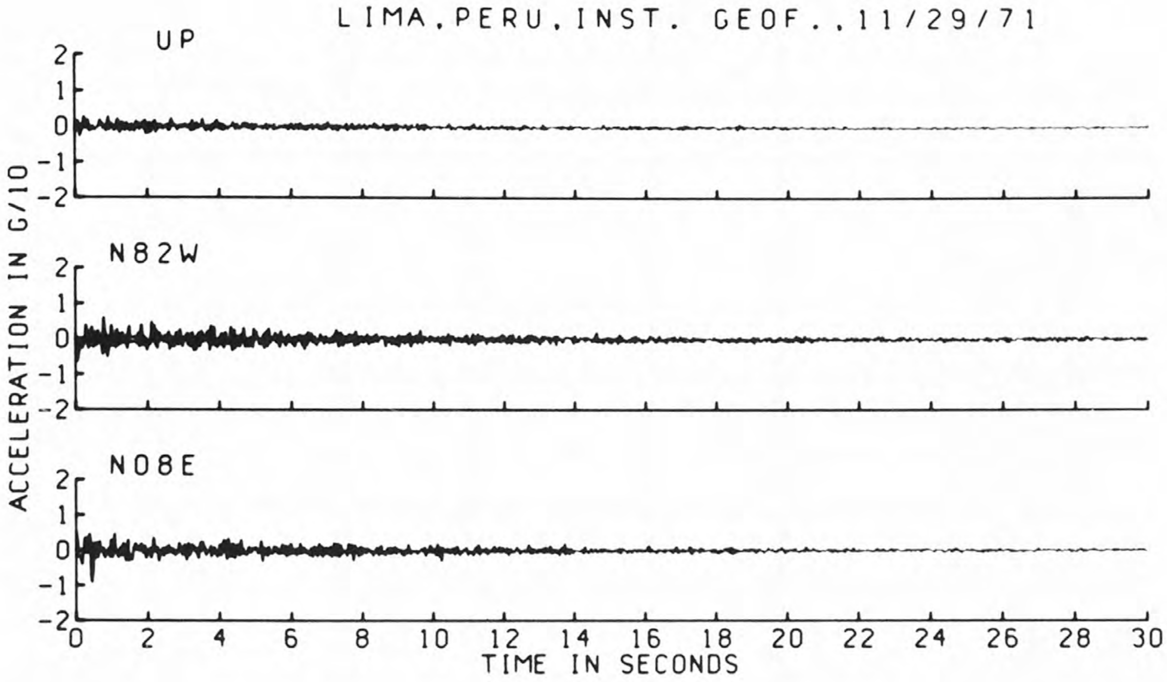

RESPONSE SPECTRA
LIMA,PERU.INST GEOFISICO.5/31/70,L COMP
0,2,5.10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
.04
.1
.2
.4
1
2
4
10
20

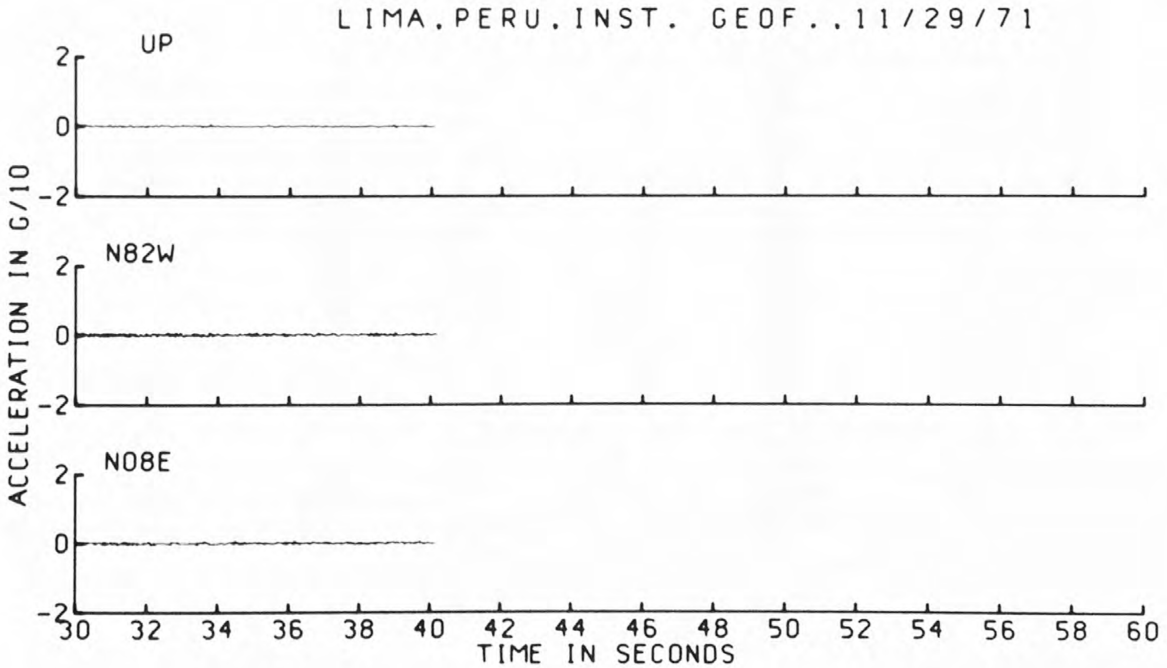

RESPONSE SPECTRA
LIMA,PERU,INST GEOFISICO,5/31/70,T COMP
0,2,5,10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
VELOCITY RESPONSE-CM/SEC
ACCELERATION-G
10.0
1.0
.10
.01
.001
DISPLACEMENT-CM
1000
100
10
1.0
.10
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS


DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST GEOF, 5/31/70, V COMP
UNITS=CM/SEC
2.5-5.0,
5.0-7.5,
7.5-10.0,
10.0-12.5,
12.5+
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
0
1
2
3
4
0
14
28

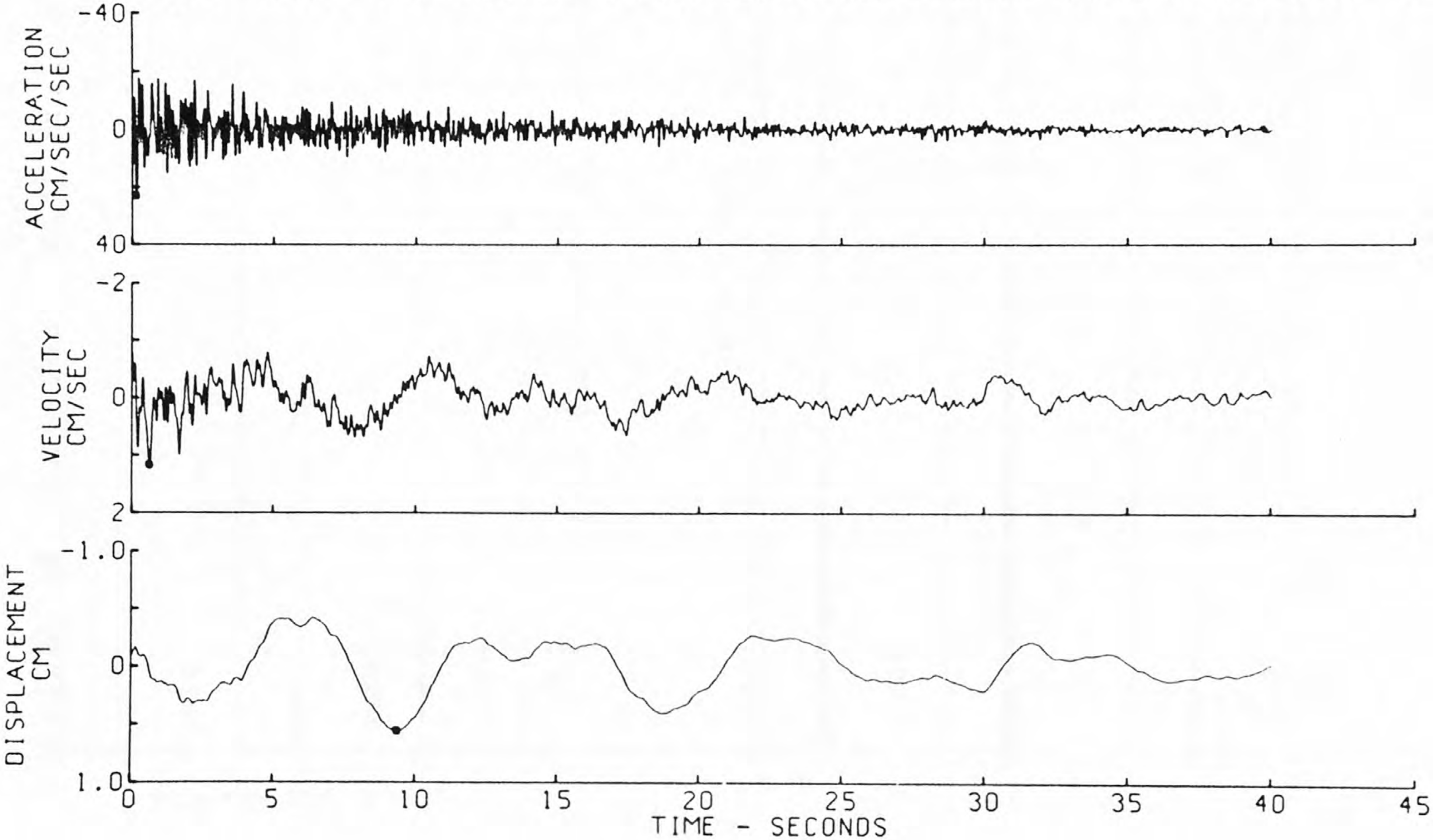

DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST GEOF, 5/31/70, L COMP
UNITS=CM/SEC
5-10.
10-15.
15+
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
0
1
2
3
4
0
4
8
12
16


DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST GEOF, 5/31/70, T COMP
UNITS=CM/SEC
5-10.
10-15.
15+
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
0
1
2
3
4
0
4
8
12
16

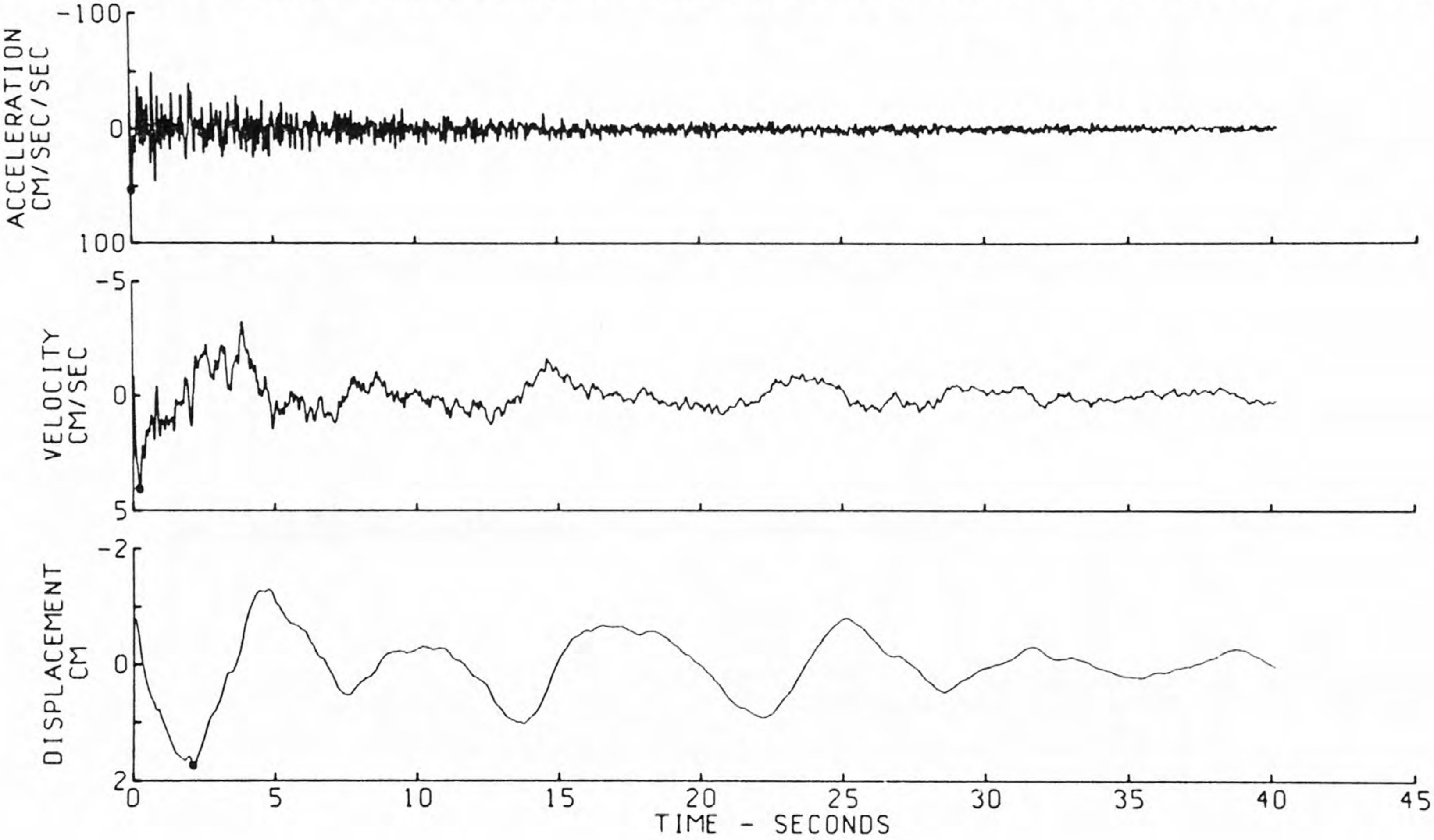

LIMA, PERU, INST. GEOF., 11/29/71
UP
N82W
N08E
ACCELERATION IN G/10
TIME IN SECONDS


LIMA, PERU, INST. GEOF., 11/29/71
UP
N82W
N08E
ACCELERATION IN G/10
TIME IN SECONDS

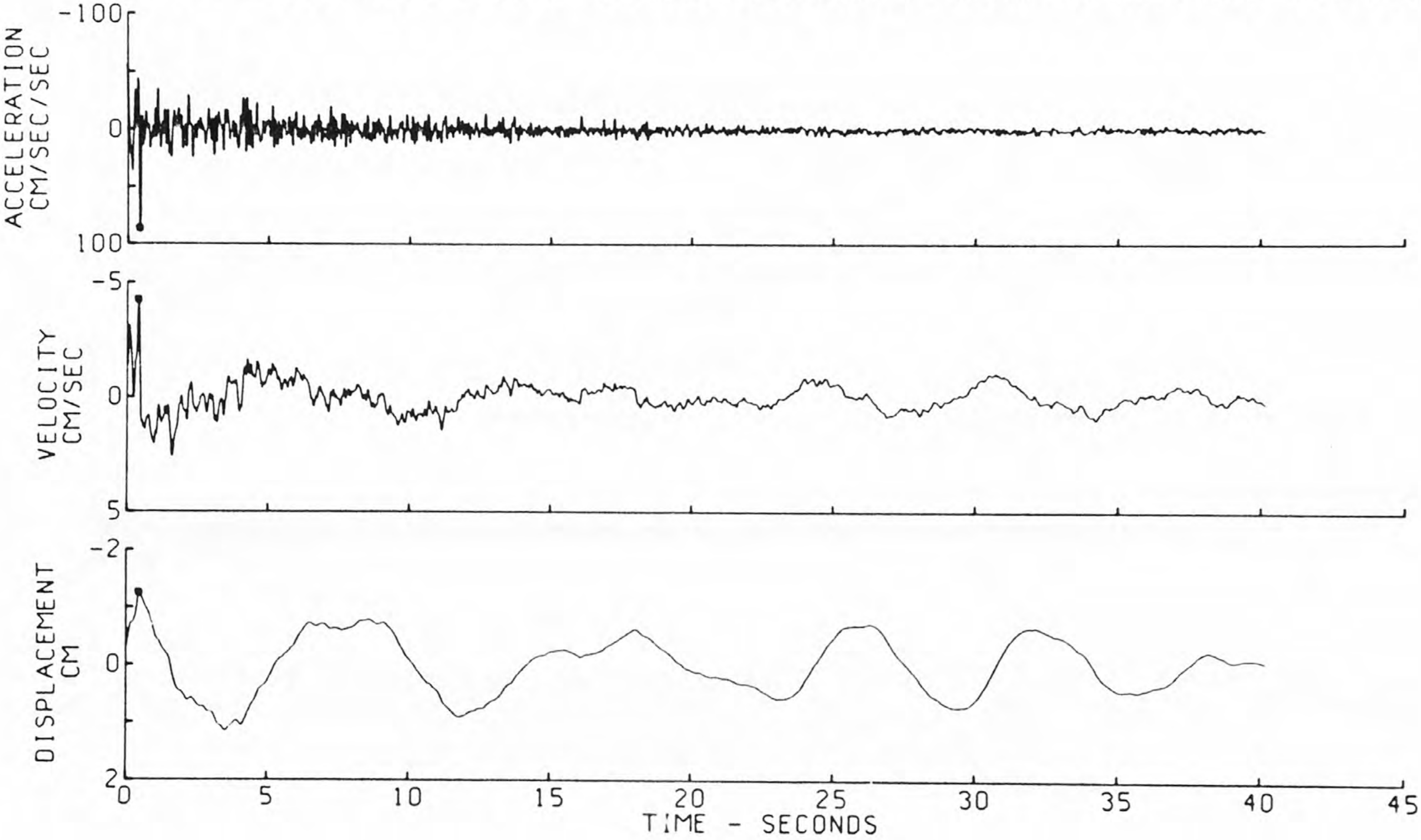
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF NOVEMBER 29, 1971
INSTITUTO GEOFISICO DEL PERU, UP COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .070 - .100 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=23.00 CM/SEC/SEC, VELOCITY=1.170 CM/SEC, DISPL=.560 CM

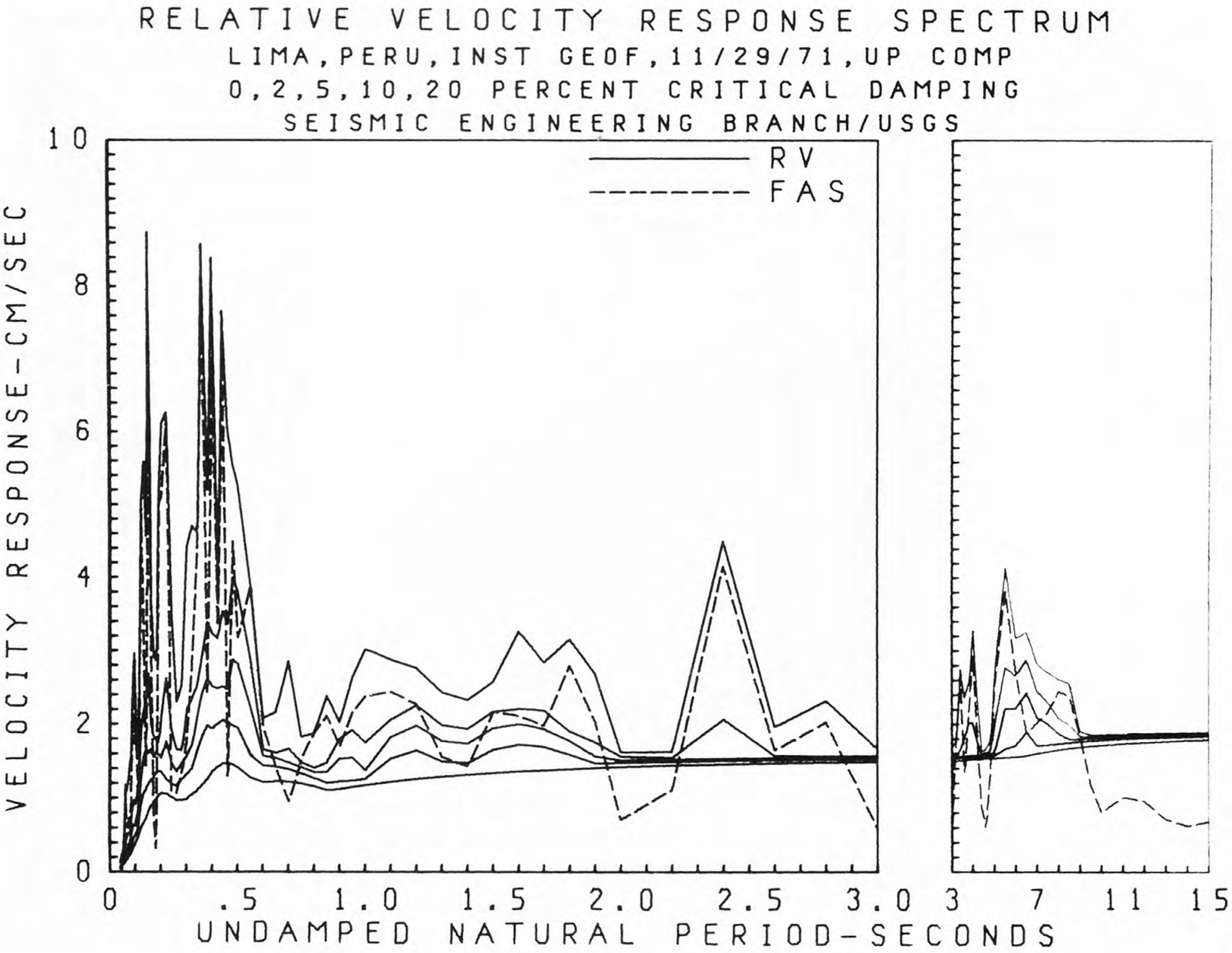


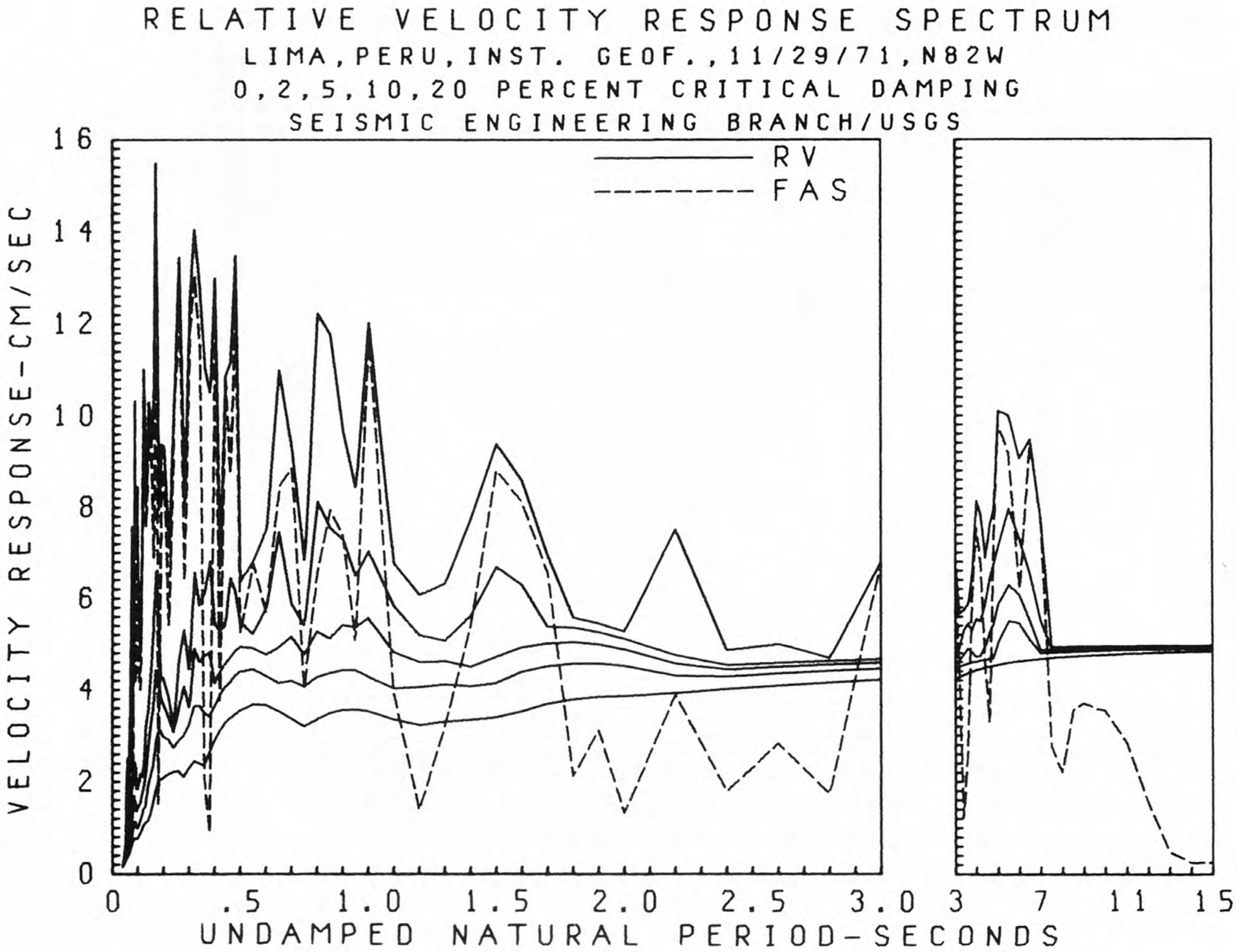
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF NOVEMBER 29, 1971
INSTITUTO GEOFISICO DEL PERU, N82W COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .070 - .100 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=53.55 CM/SEC/SEC, VELOCITY=4.080 CM/SEC, DISPL=1.740 CM

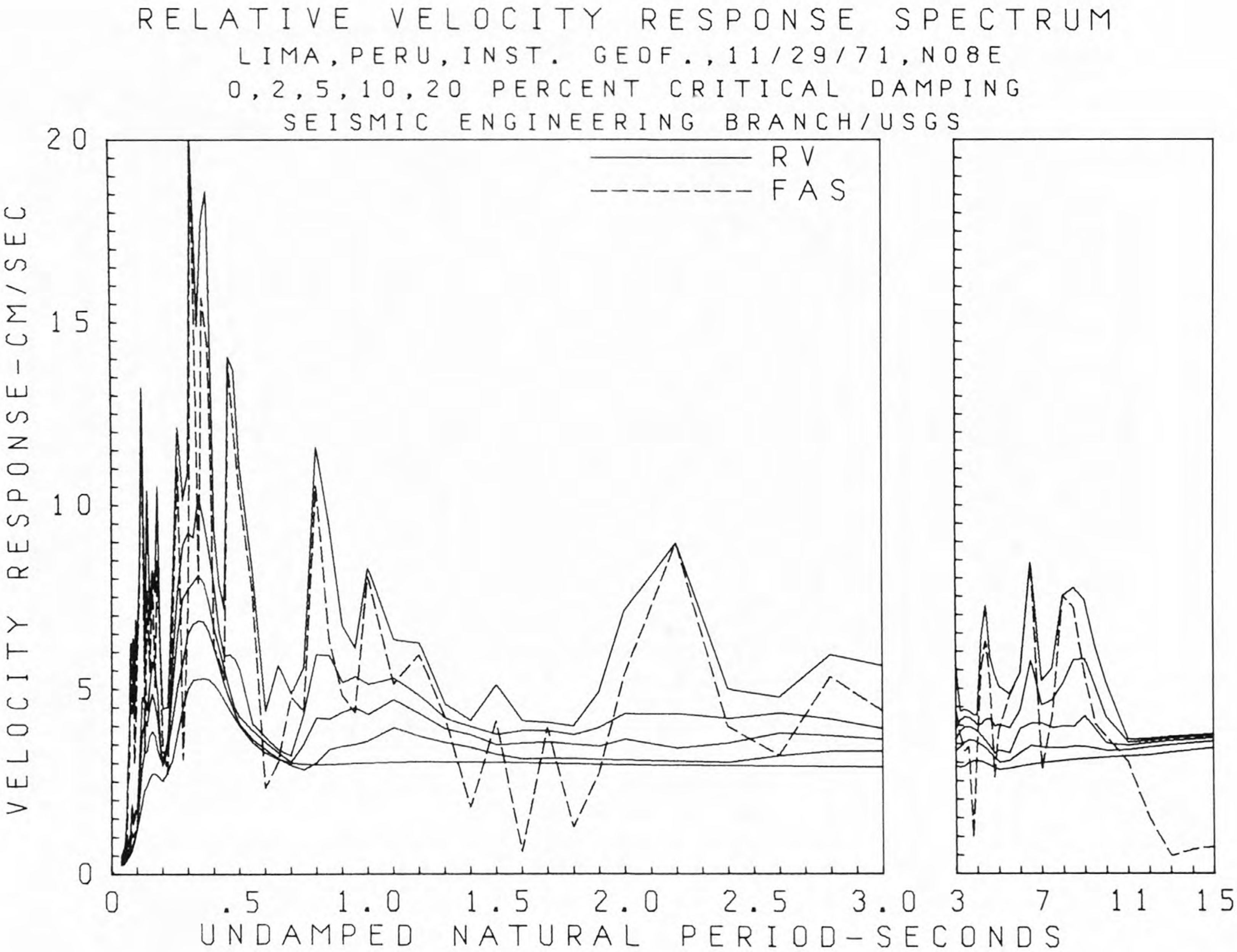


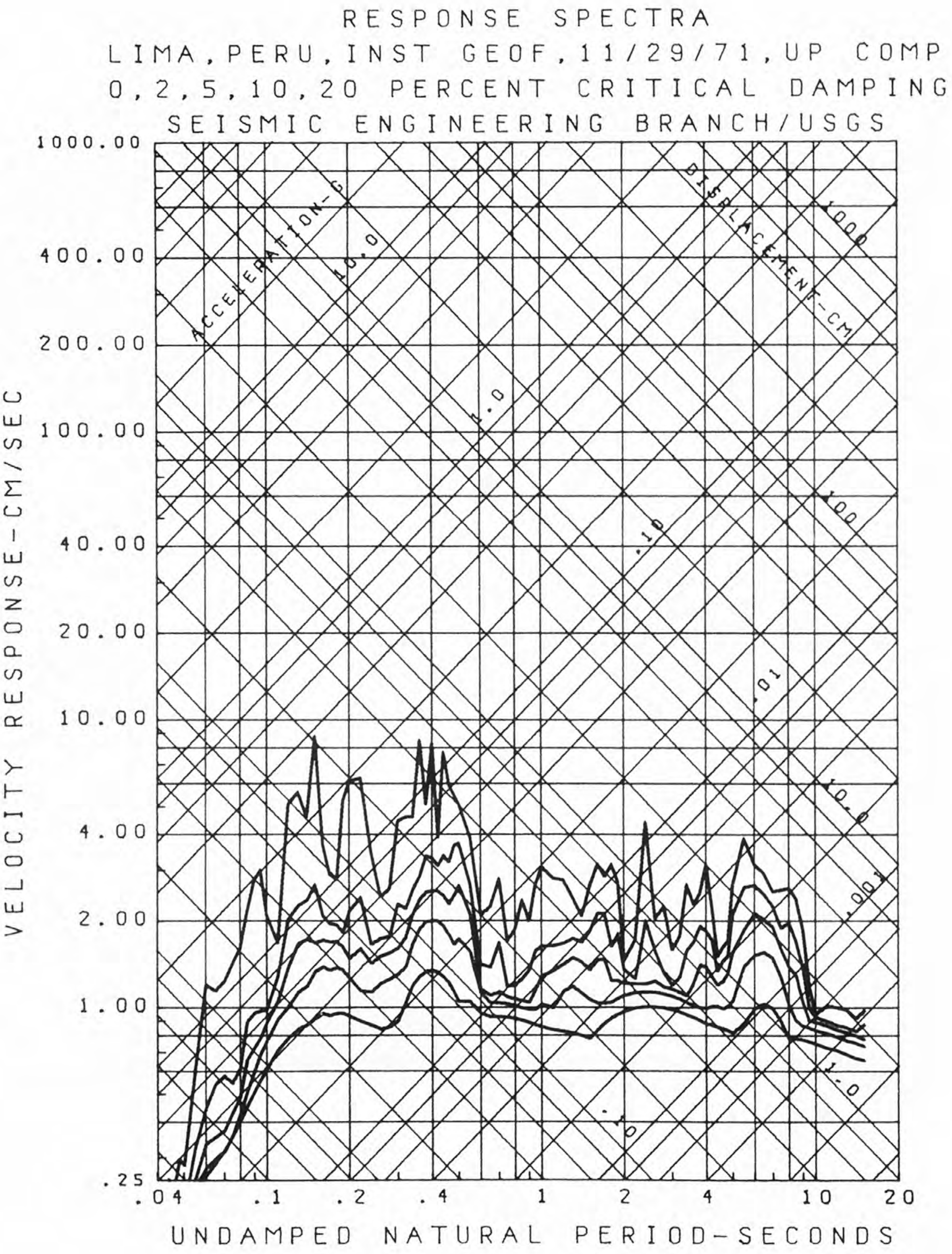
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF NOVEMBER 29, 1971
INSTITUTO GEOFISICO DEL PERU, N08E COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .070 - .100 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=86.54 CM/SEC/SEC, VELOCITY=-4.220 CM/SEC, DISPL=-1.250 CM

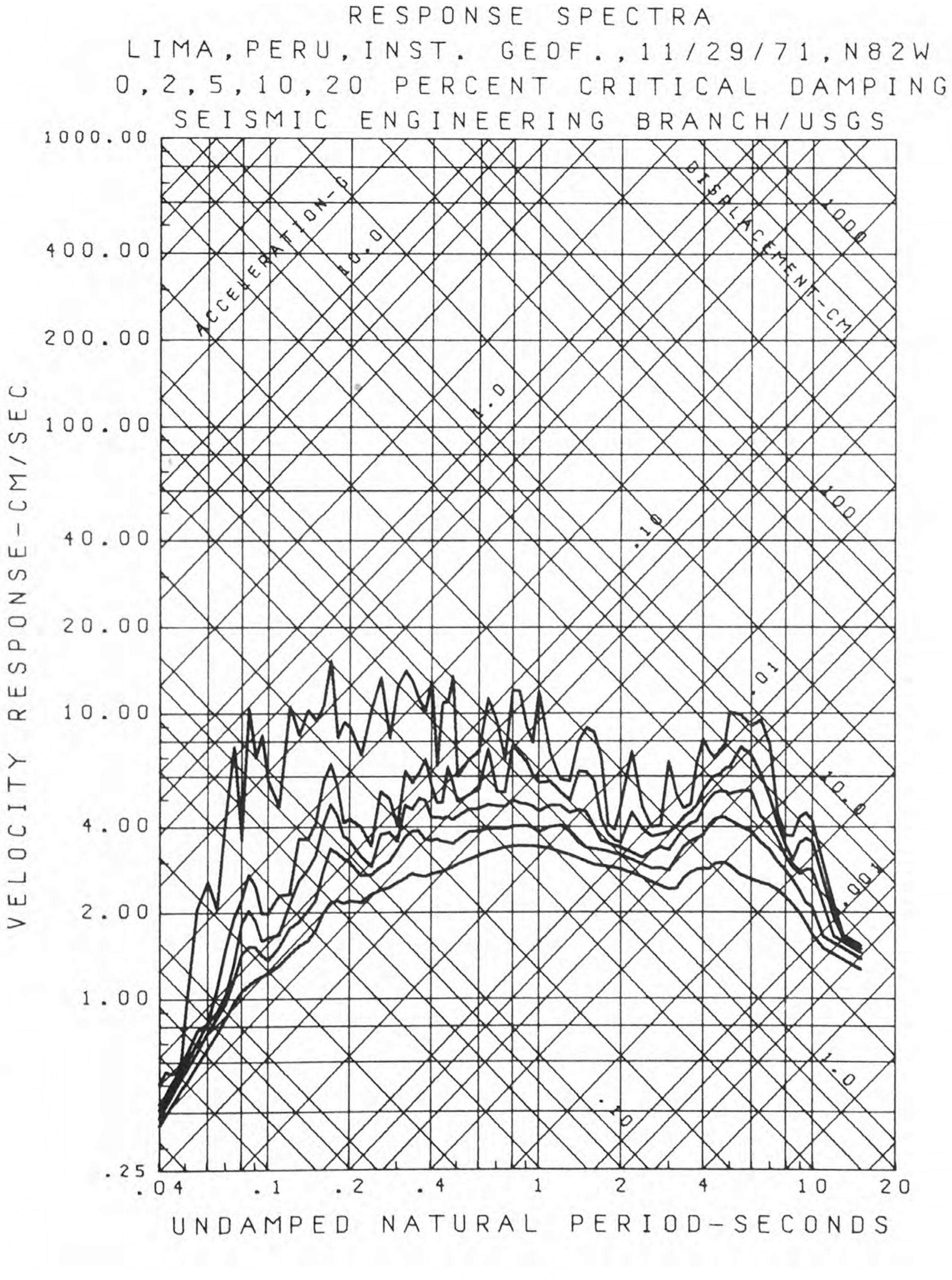


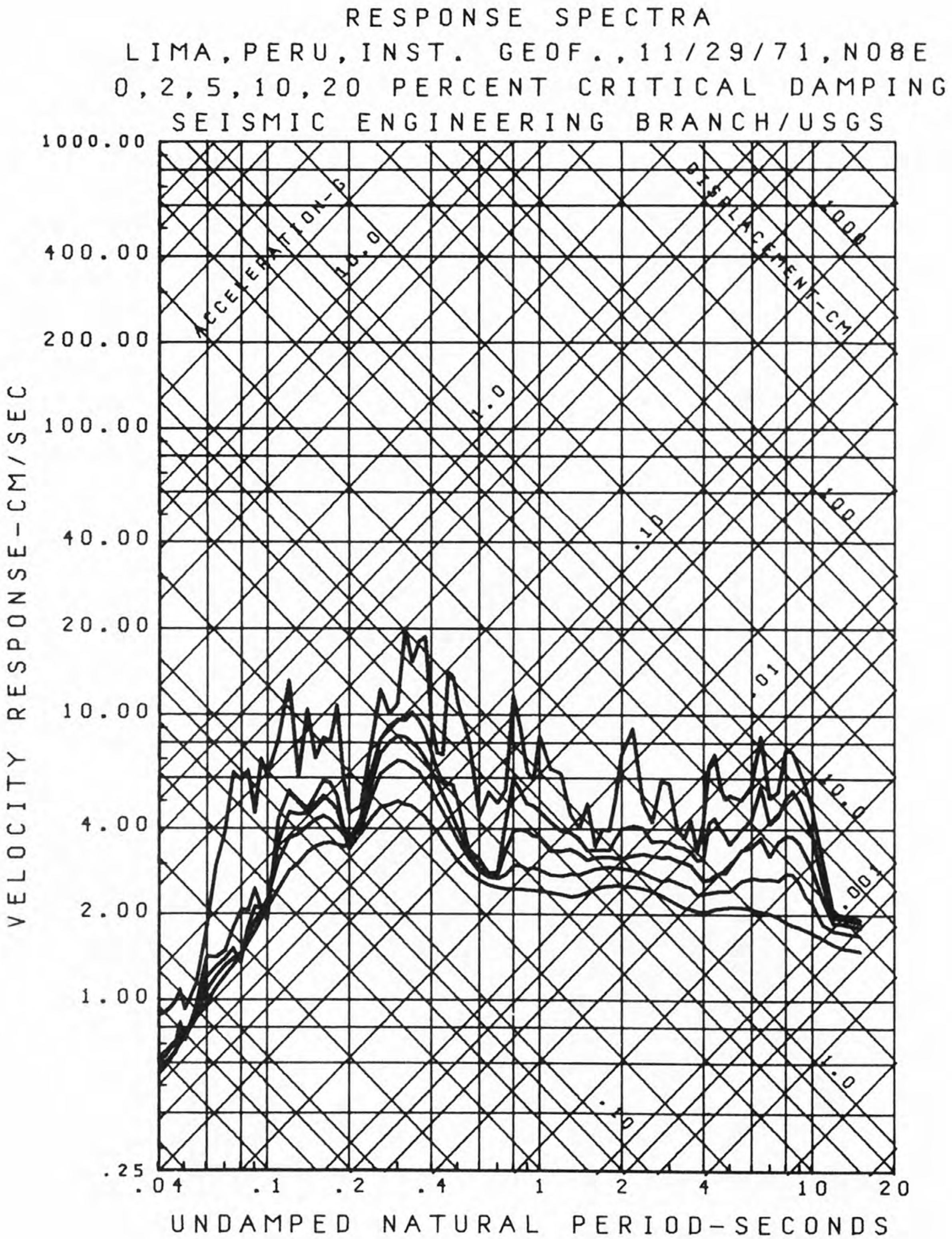

RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST GEOF, 11/29/71, UP COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
0
2
4
6
8
10
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

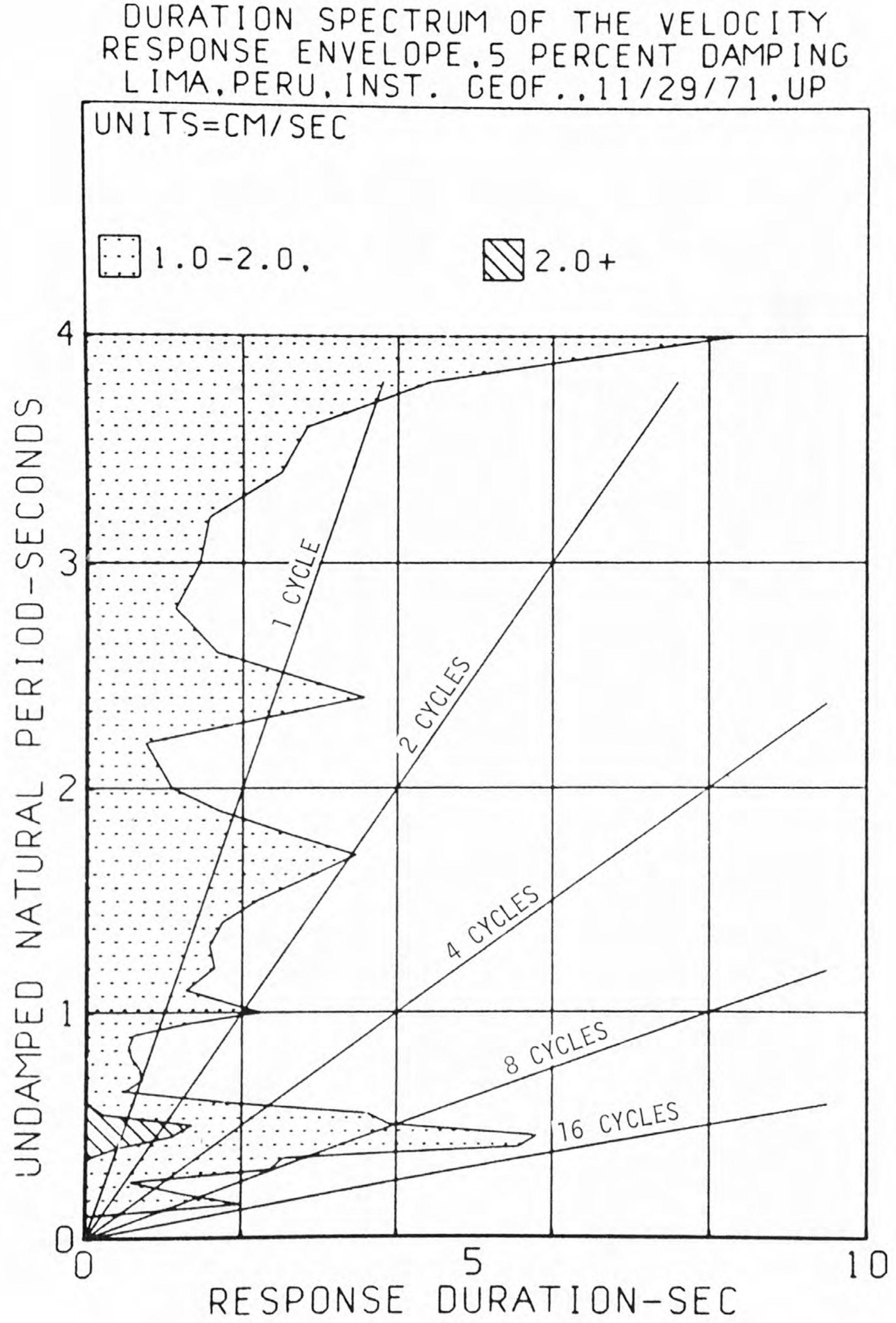

RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA,PERU,INST. GEOF.,11/29/71,N82W
0,2,5,10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
0
2
4
6
8
10
12
14
16
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

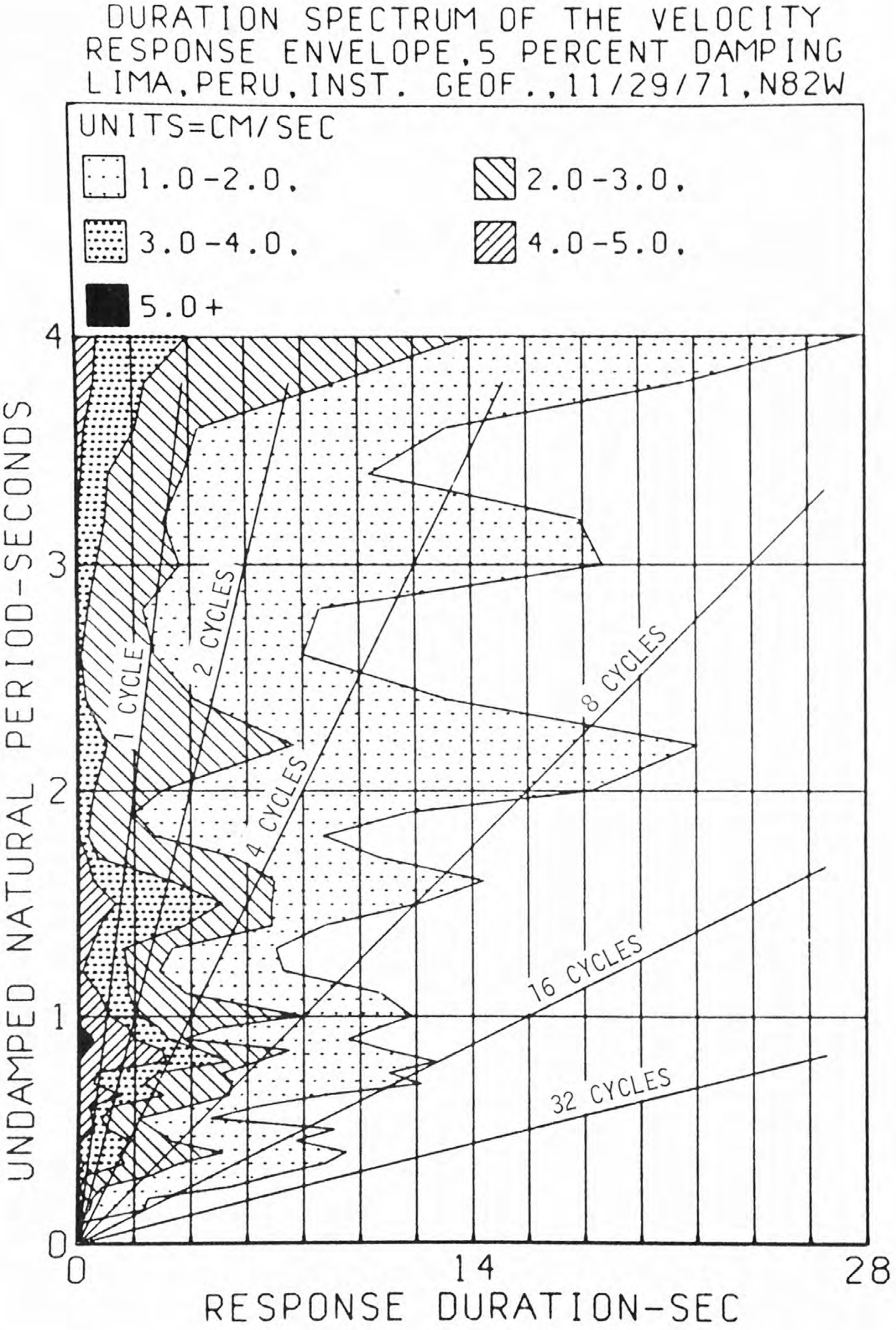

RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST. GEOF., 11/29/71, N08E
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
0
5
10
15
20
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15

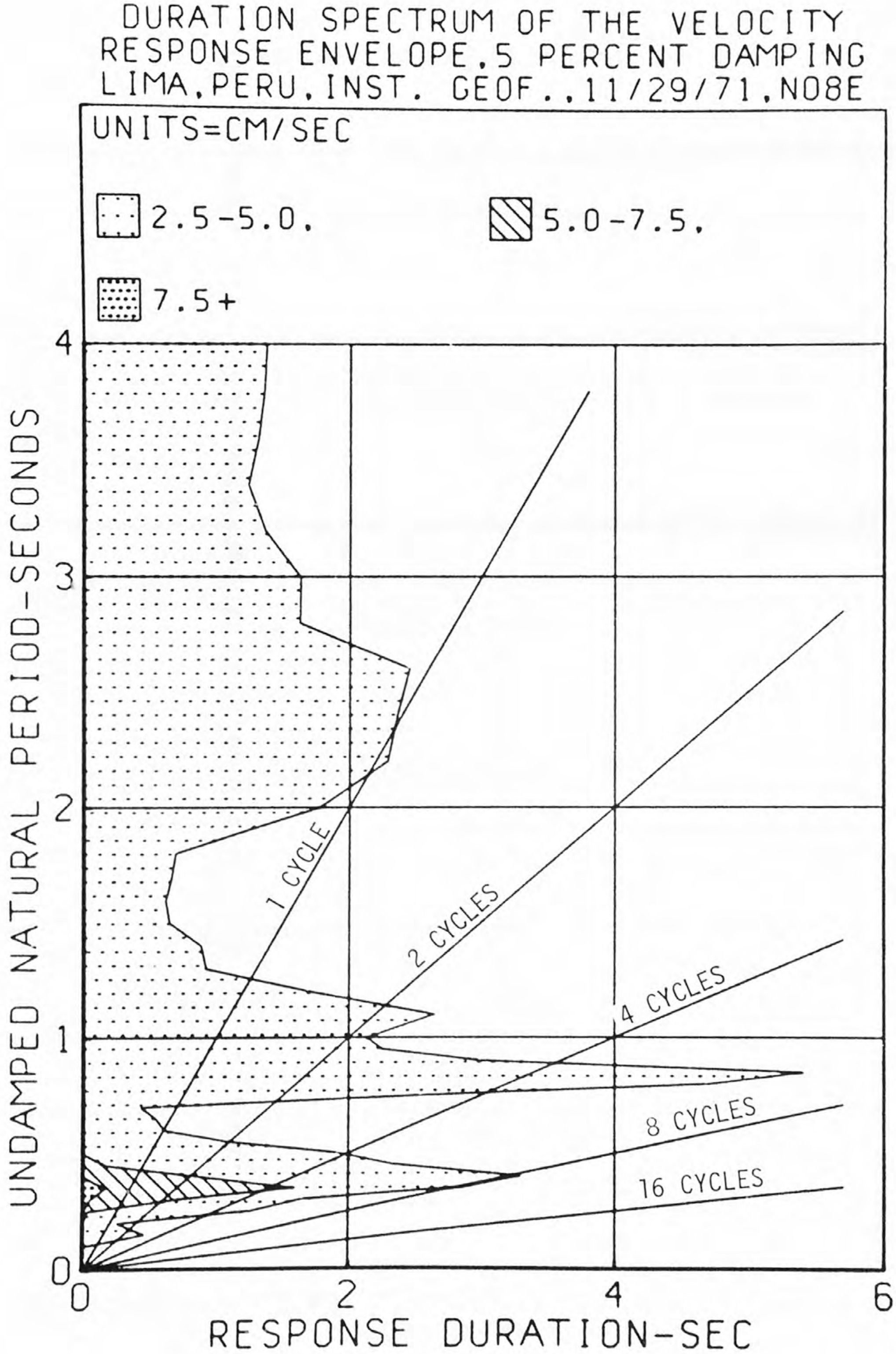

RESPONSE SPECTRA
LIMA,PERU,INST GEOF,11/29/71,UP COMP
0,2,5,10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
.04
.1
.2
.4
1
2
4
10
20

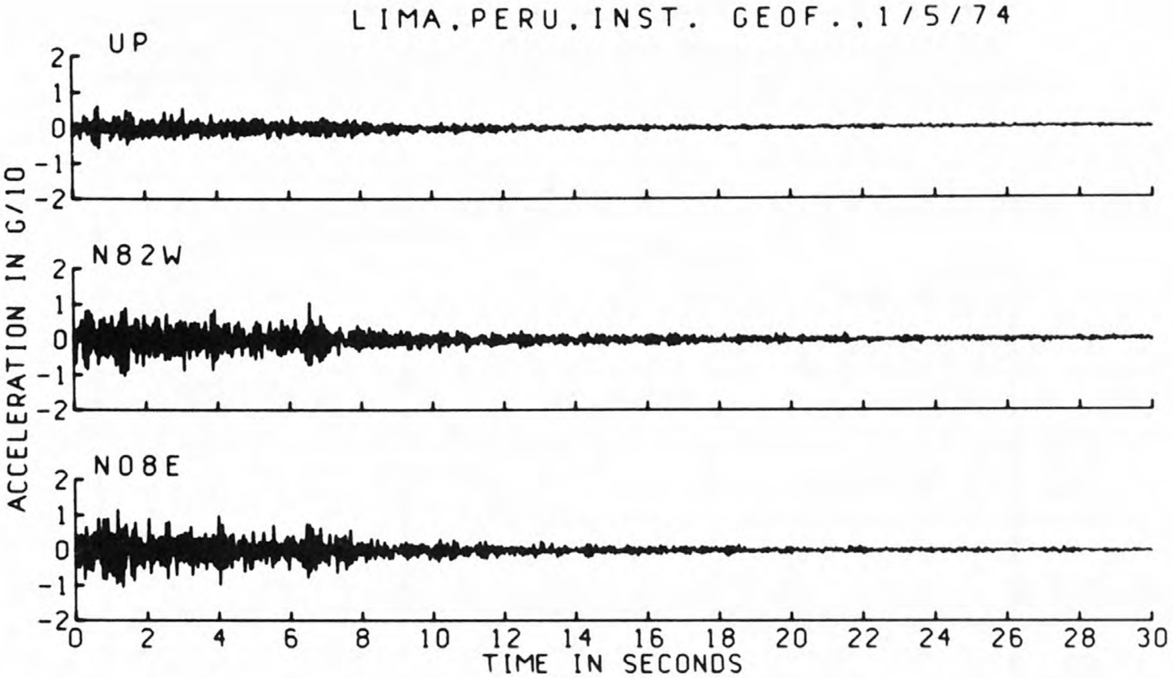

RESPONSE SPECTRA
LIMA,PERU,INST. GEOF.,11/29/71,N82W
0,2,5,10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
.04
.1
.2
.4
1
2
4
10
20


RESPONSE SPECTRA
LIMA, PERU, INST. GEOF., 11/29/71, N08E
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
ACCELERATION-G
10.0
1.0
.10
.01
.001
DISPLACEMENT-CM
1000
100
10.0
1.0
.10
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS

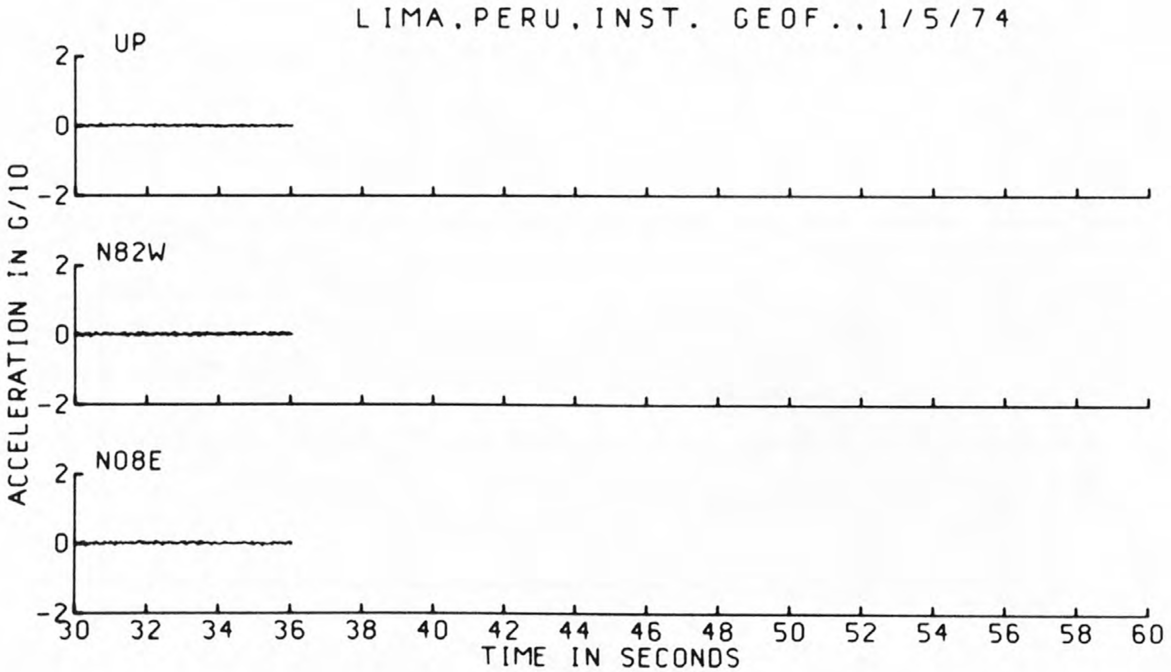

DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE,5 PERCENT DAMPING
LIMA,PERU,INST. GEOF.,11/29/71,UP
UNITS=CM/SEC
1.0-2.0,
2.0+
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
0
1
2
3
4
0
5
10


DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST. GEOF., 11/29/71, N82W
UNITS=CM/SEC
1.0-2.0.
2.0-3.0.
3.0-4.0.
4.0-5.0.
5.0+
UNDAMPED NATURAL PERIOD-SECONDS
0
1
2
3
4
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
0
14
28
RESPONSE DURATION-SEC


DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST. GEOF., 11/29/71, N08E
UNITS=CM/SEC
2.5-5.0,
5.0-7.5,
7.5+
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
0
1
2
3
4
0
2
4
6

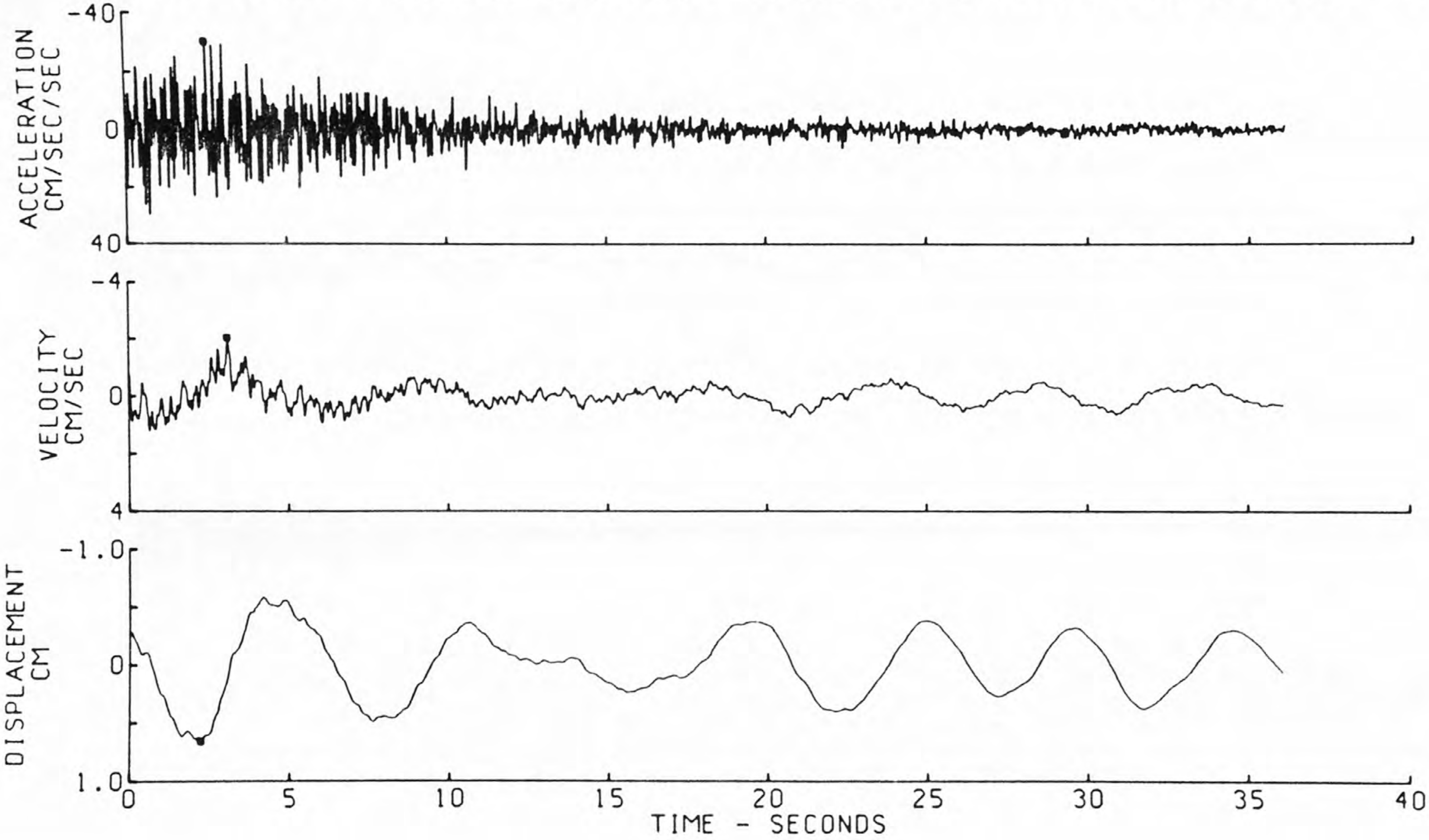


LIMA.PERU.INST. GEOF..1/5/74
UP
N82W
N08E
ACCELERATION IN G/10
TIME IN SECONDS

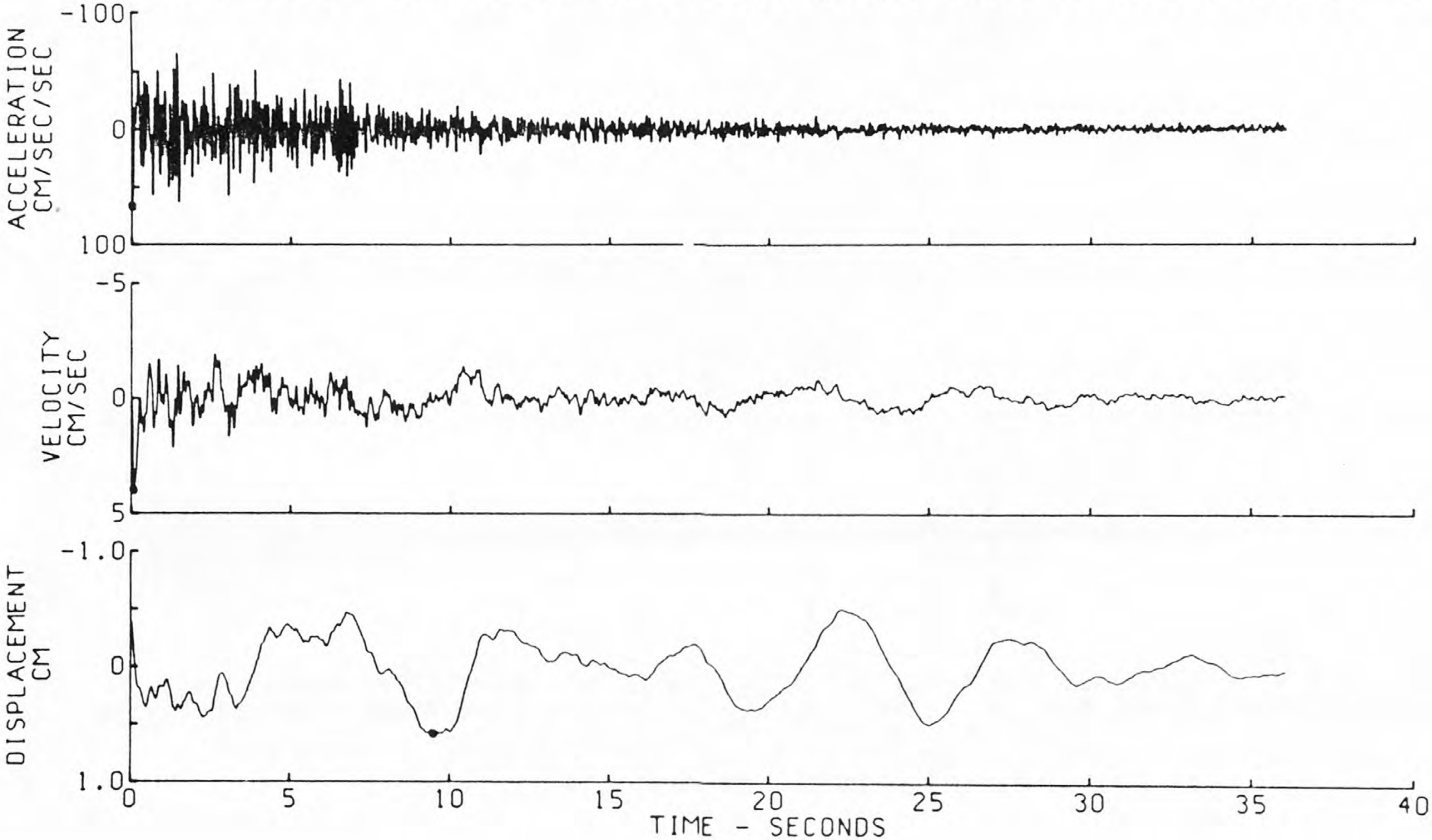


LIMA.PERU.INST. GEOF..1/5/74
UP
N82W
N08E
ACCELERATION IN G/10
TIME IN SECONDS

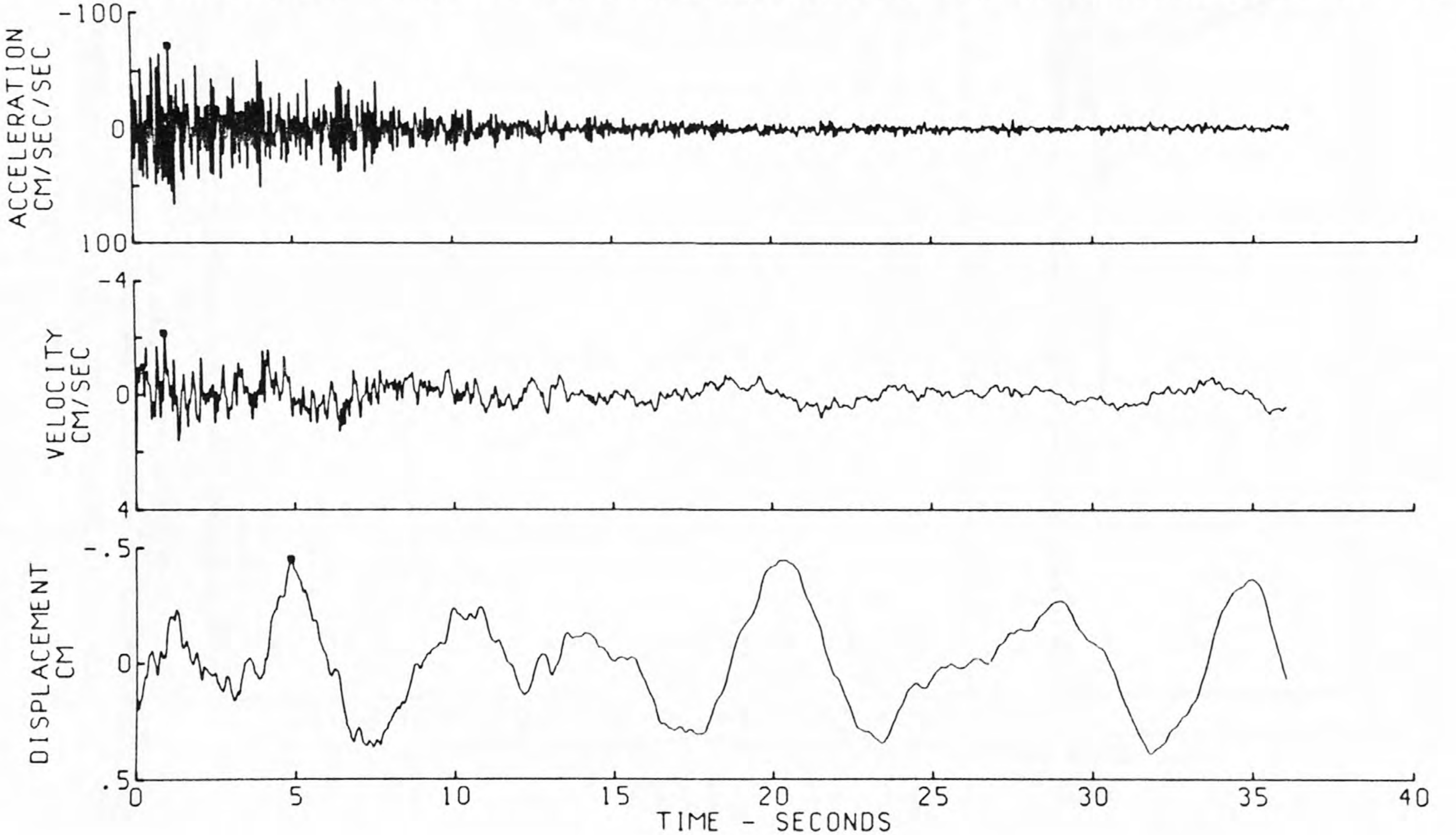
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF JANUARY 5, 1974
INSTITUTO GEOFISICO DEL PERU, UP COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .090 - .125 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-30.32 CM/SEC/SEC, VELOCITY=-2.040 CM/SEC, DISPL=.660 CM

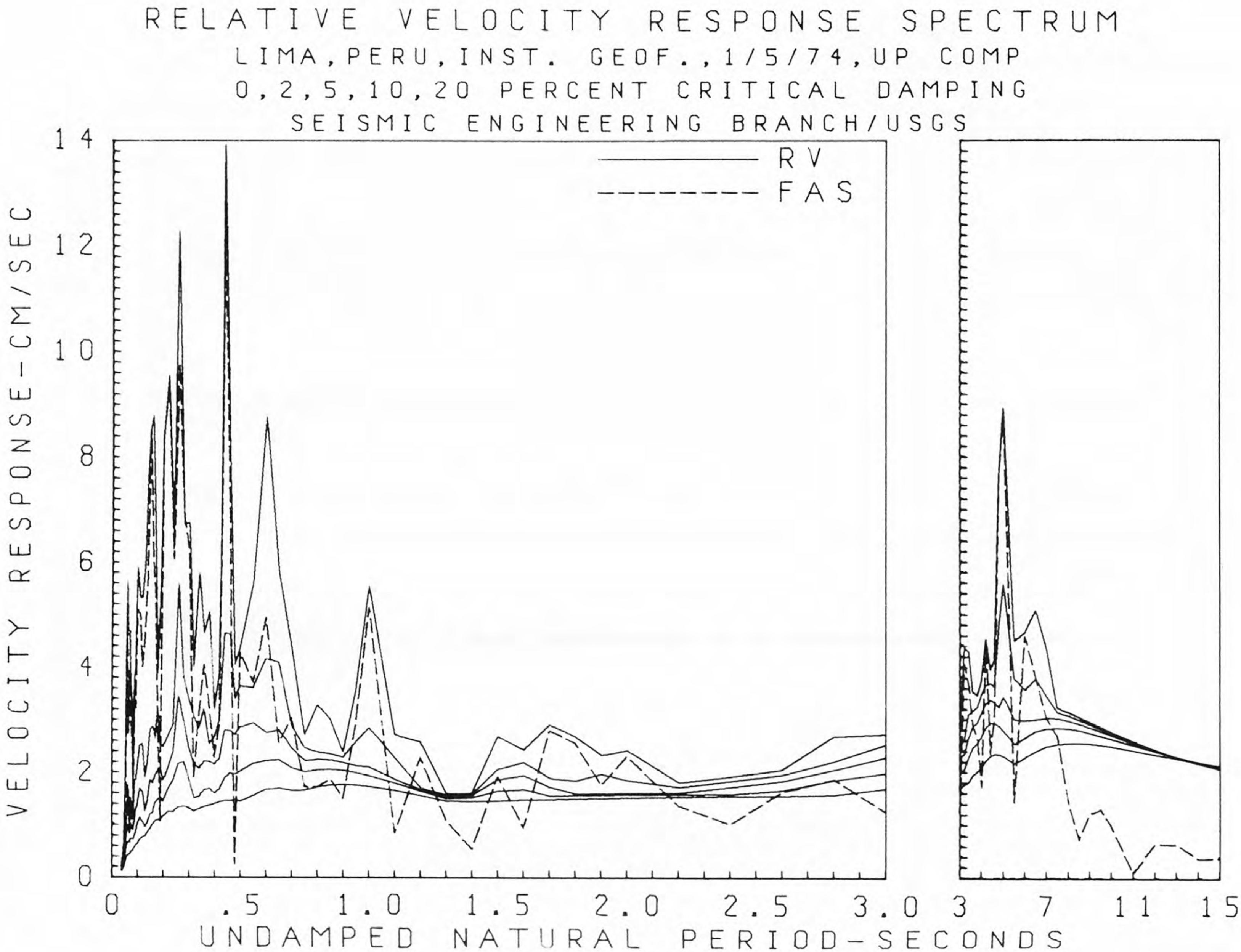


CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF JANUARY 5, 1974
INSTITUTO GEOFISICO DEL PERU, N82W COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .090 - .125 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=66.76 CM/SEC/SEC, VELOCITY=4.030 CM/SEC, DISPL=.590 CM

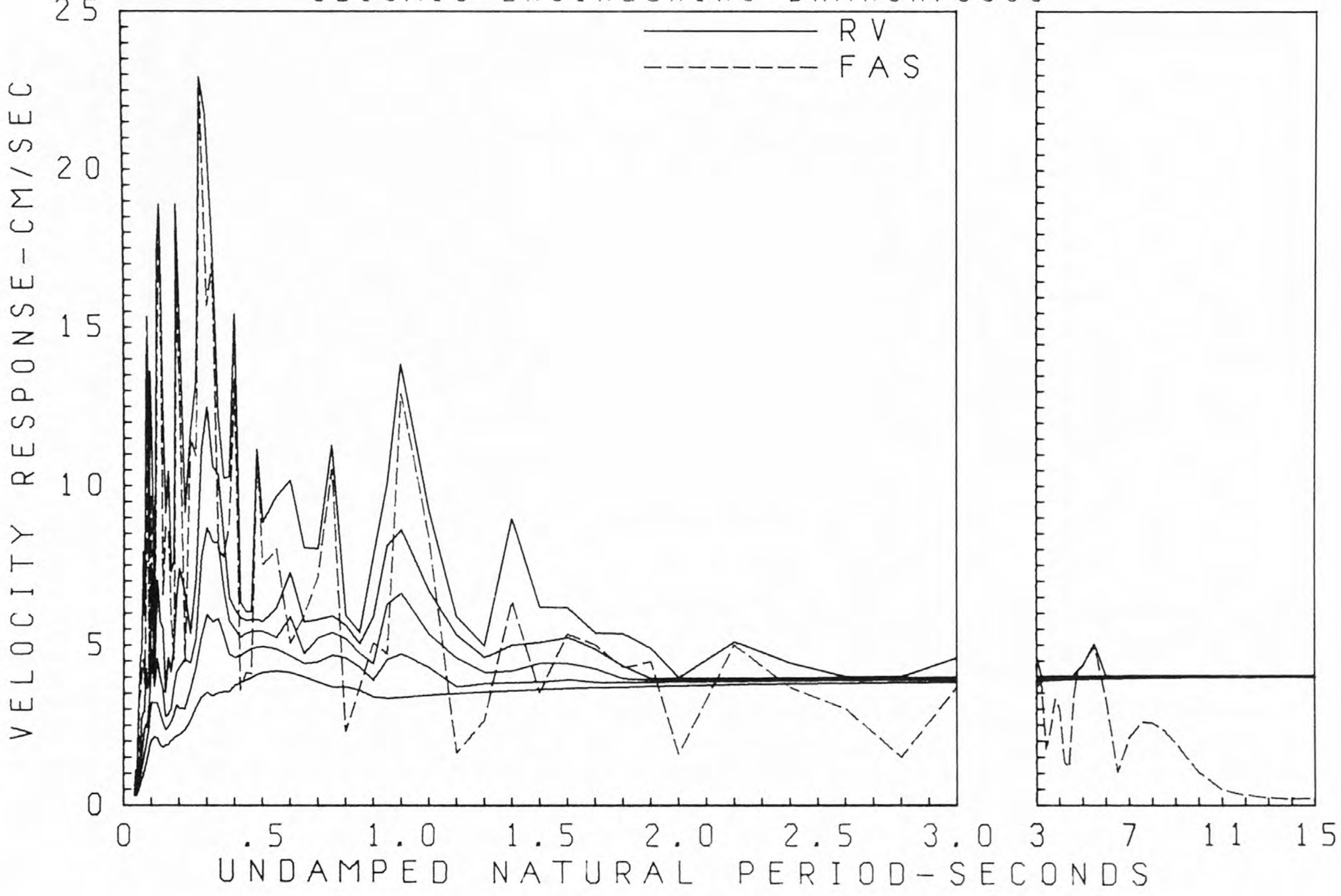


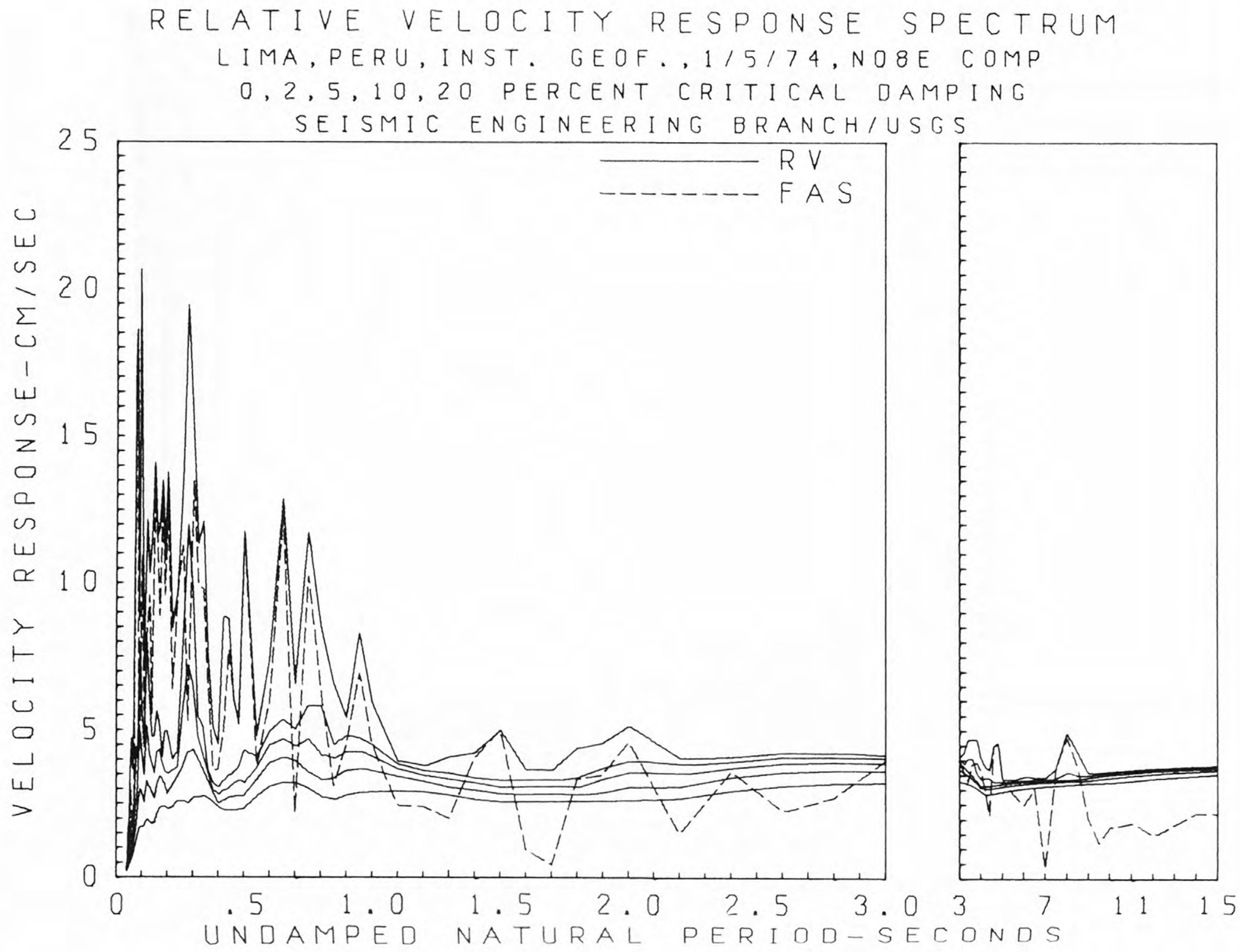
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF JANUARY 5, 1974
INSTITUTO GEOFISICO DEL PERU, N08E COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .090 - .125 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-72.28 CM/SEC/SEC, VELOCITY=-2.150 CM/SEC, DISPL=-.450 CM

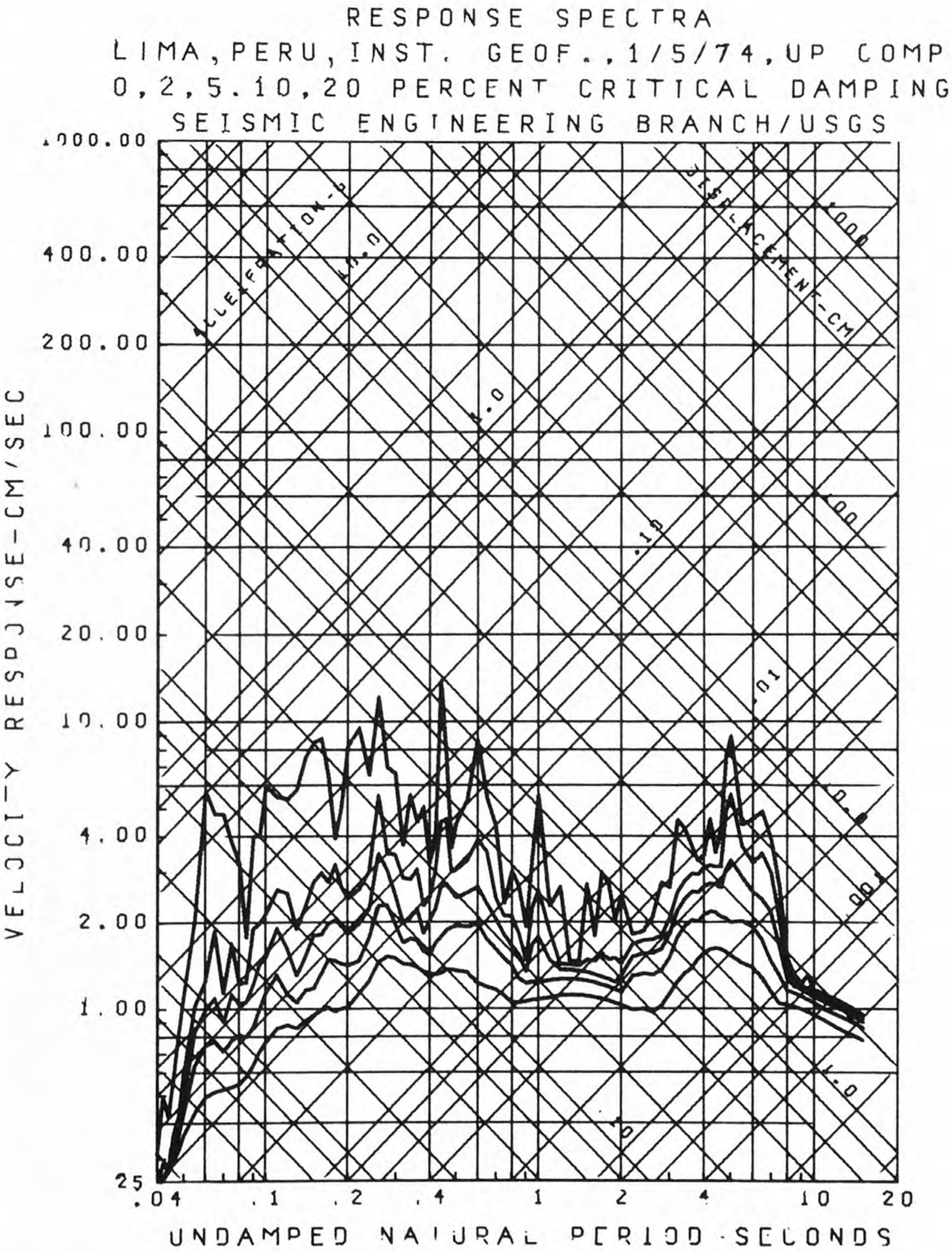



RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST. GEOF., 1/5/74, UP COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
0
2
4
6
8
10
12
14
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

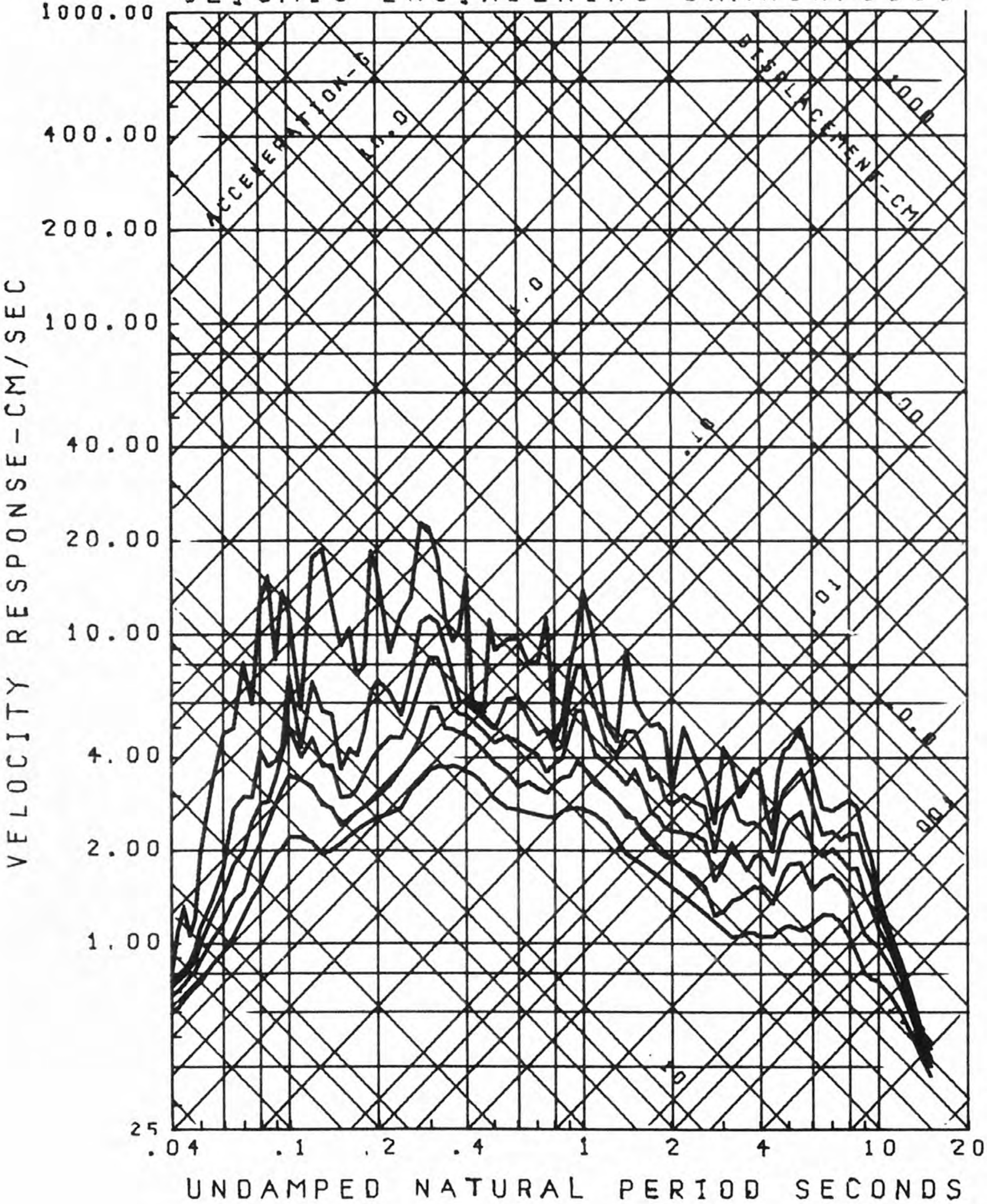
RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST. GEOF., 1/5/74, N82W COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

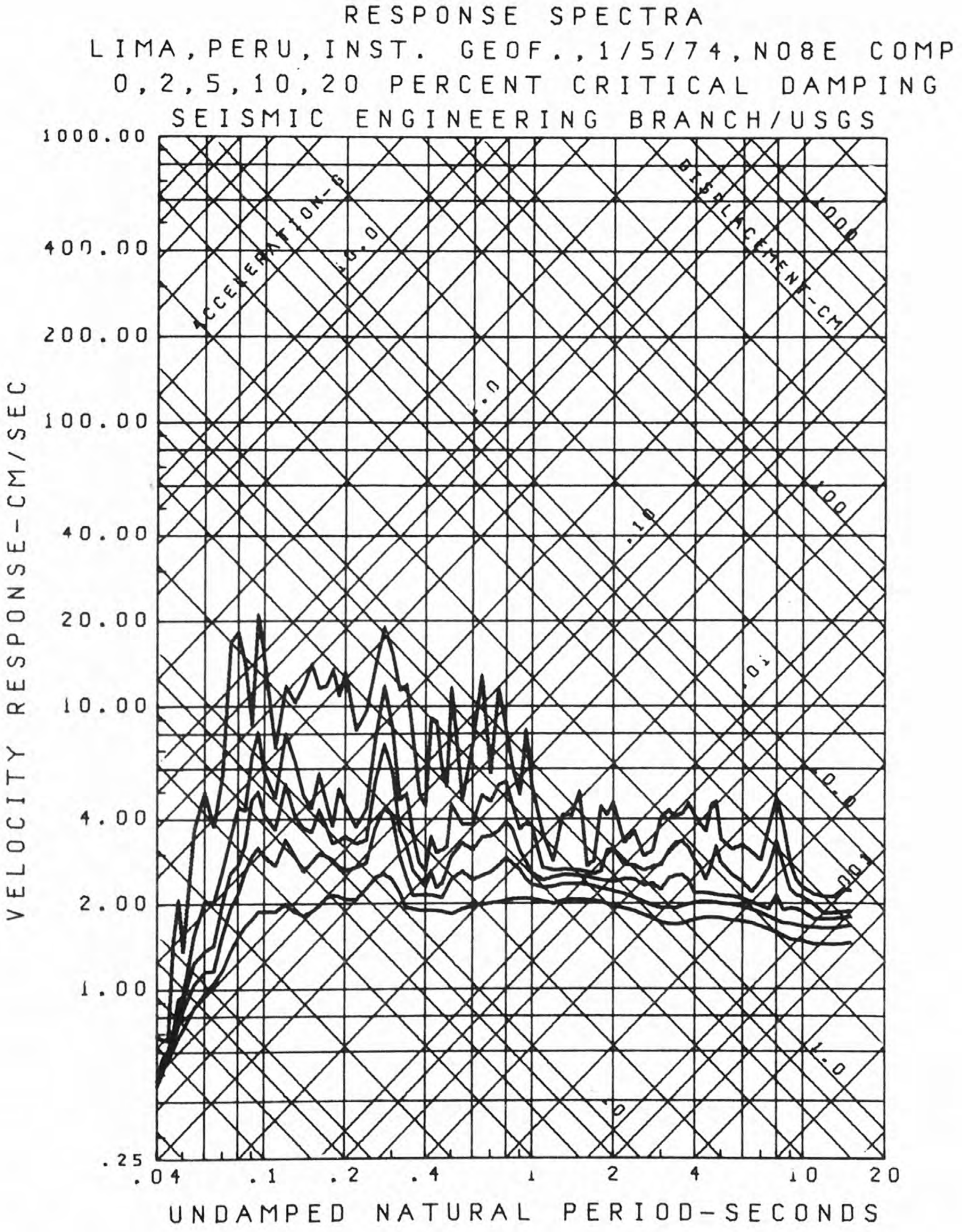


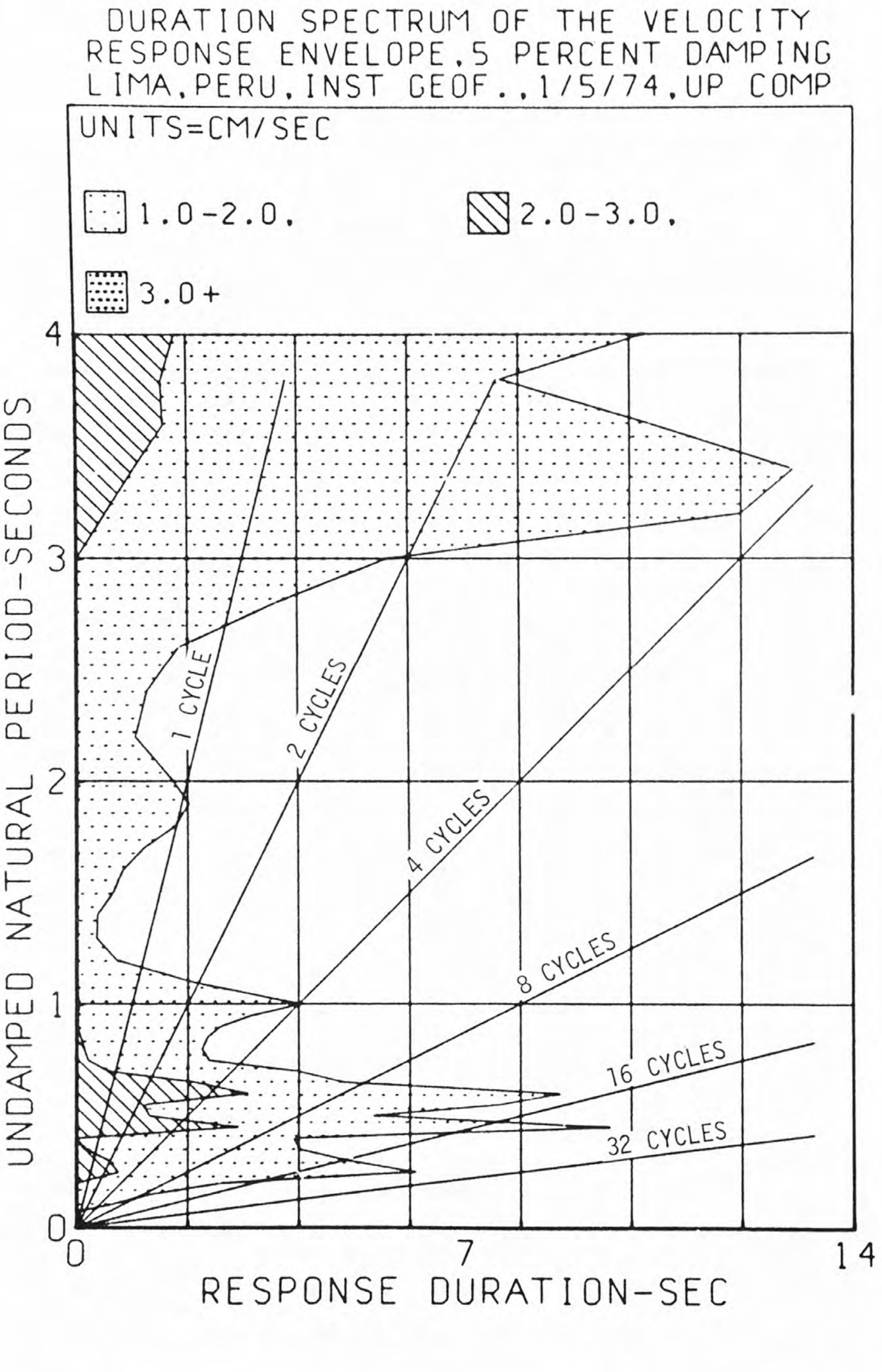

RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST. GEOF., 1/5/74, N08E COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
0
5
10
15
20
25
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

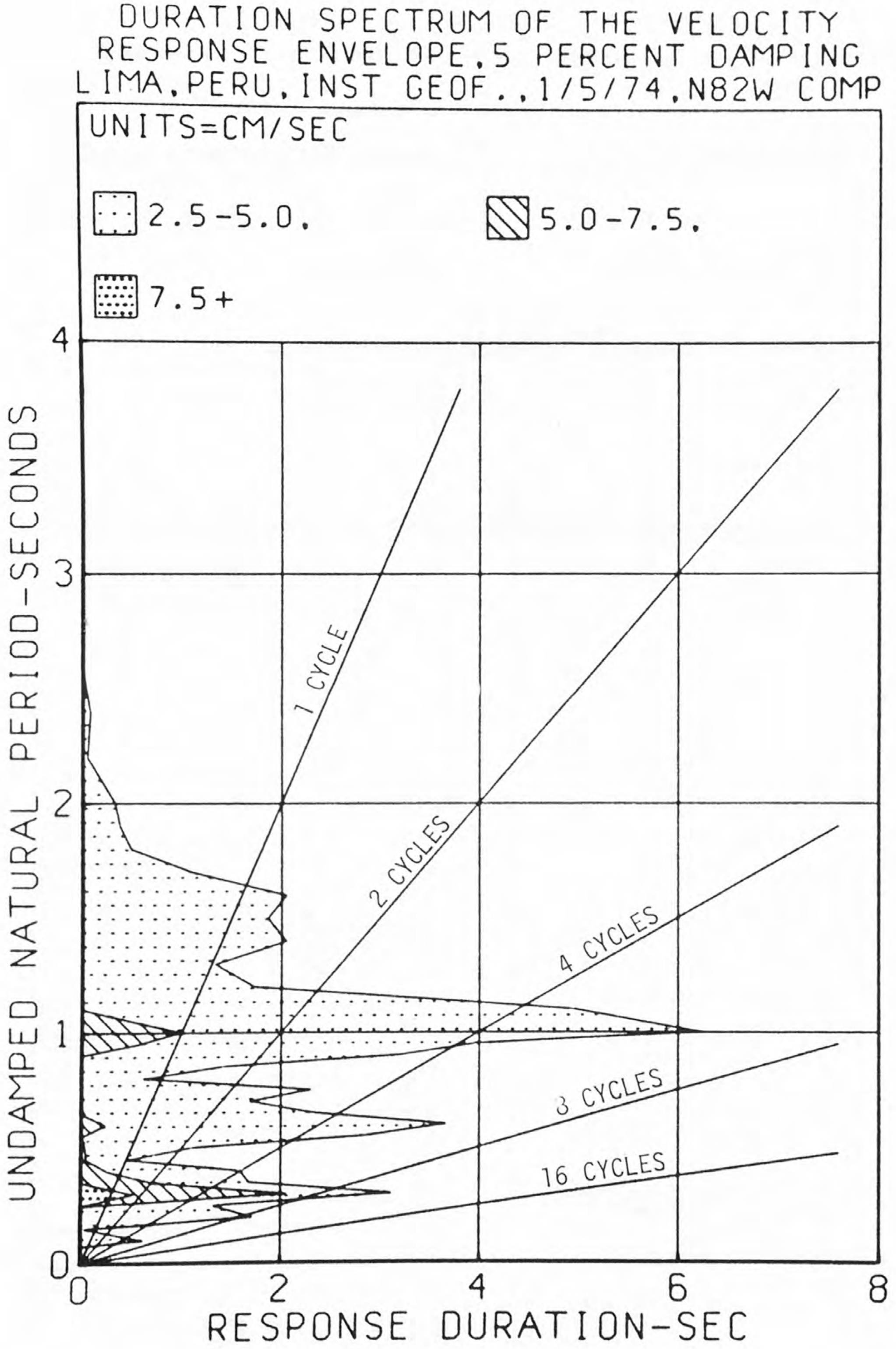

RESPONSE SPECTRA
LIMA,PERU,INST. GEOF.,1/5/74,UP COMP
0,2,5.10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM

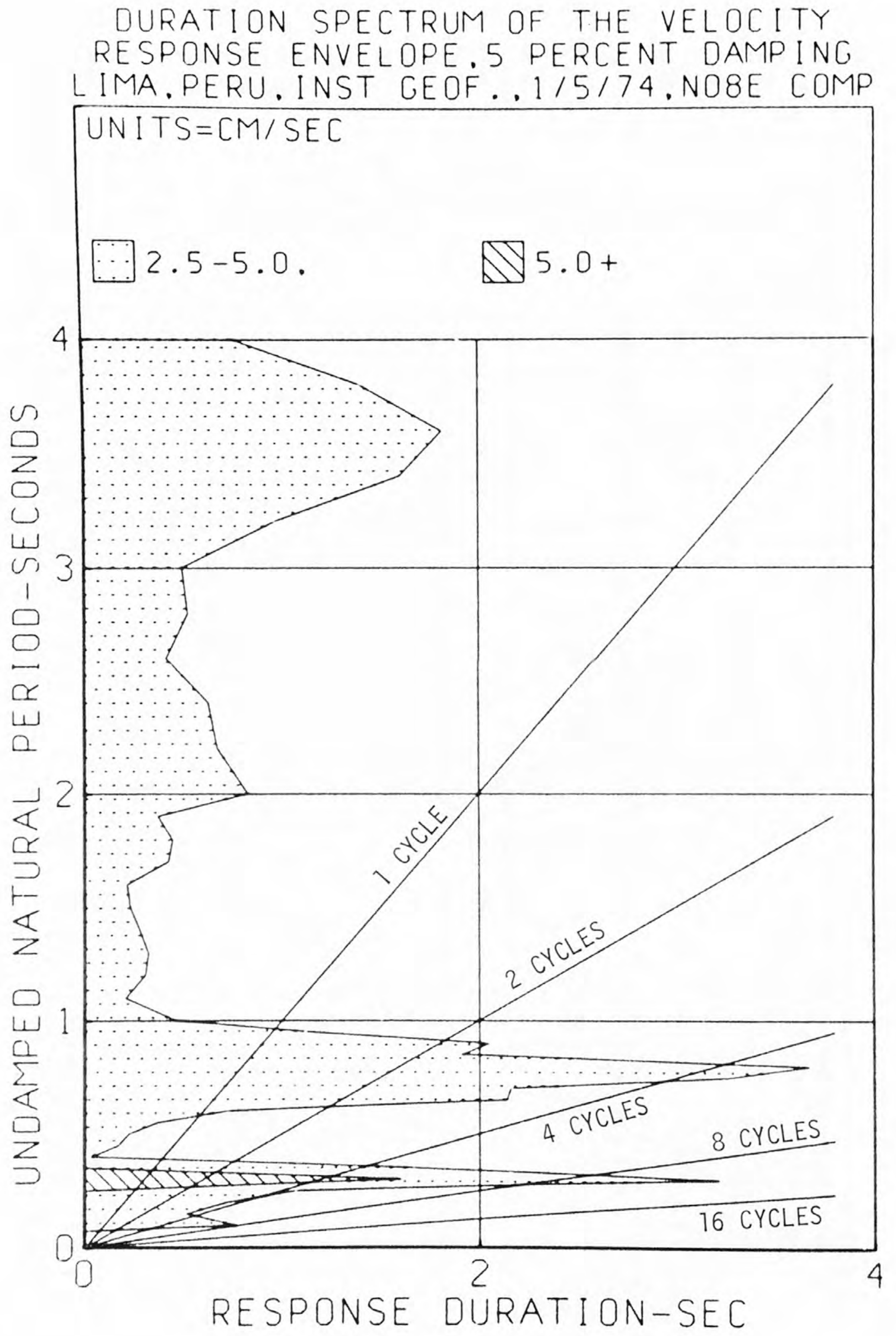
RESPONSE SPECTRA
LIMA,PERU.INST. GEOF.,1/5/74,N82W COMP
0,2.5.10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

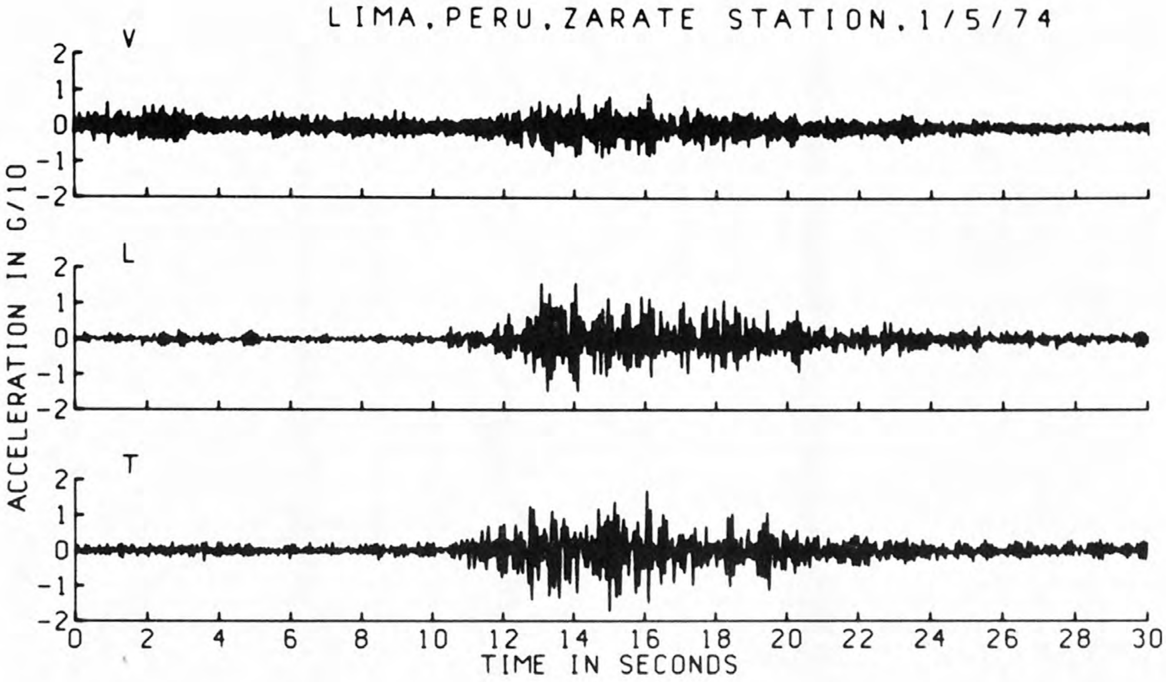


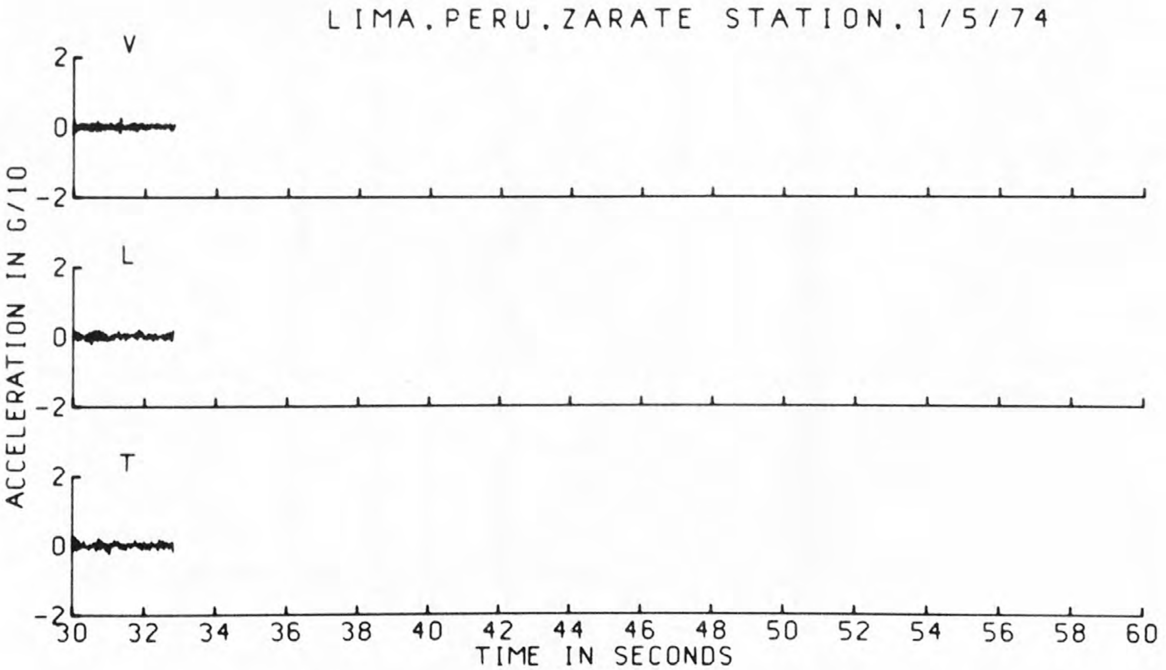

RESPONSE SPECTRA
LIMA, PERU, INST. GEOF., 1/5/74, N08E COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
.04
.1
.2
.4
1
2
4
10
20
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
1000
100
10.0
1.0
.10
.01
1.0
10.0
.001


DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST GEOF., 1/5/74, UP COMP
UNITS=CM/SEC
1.0-2.0.
2.0-3.0.
3.0+
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
0
1
2
3
4
0
7
14

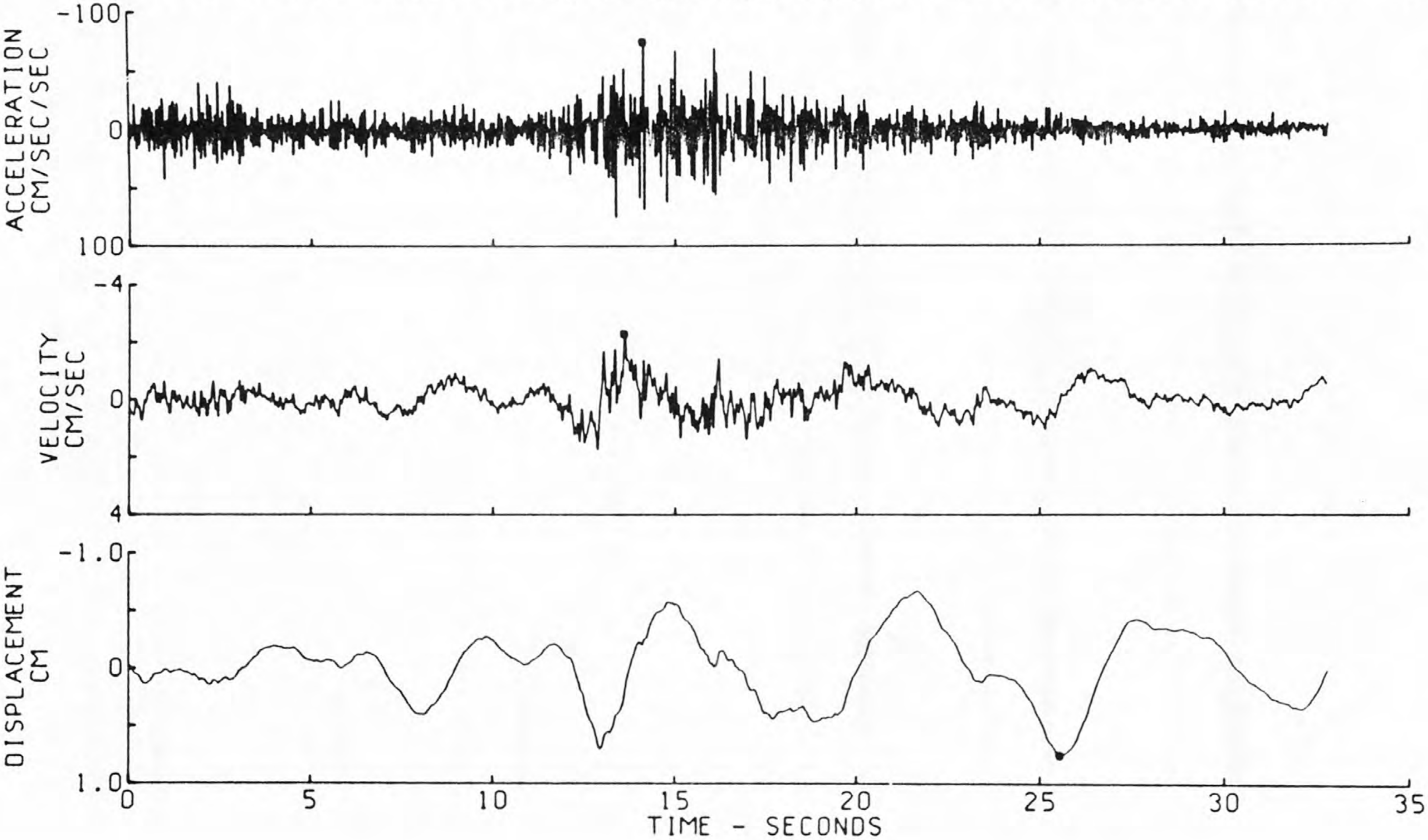

DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST GEOF., 1/5/74, N82W COMP
UNITS=CM/SEC
2.5-5.0.
5.0-7.5.
7.5+
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
0
1
2
3
4
0
2
4
6
8


DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST GEOF., 1/5/74, N08E COMP
UNITS=CM/SEC
2.5-5.0.
5.0+
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC

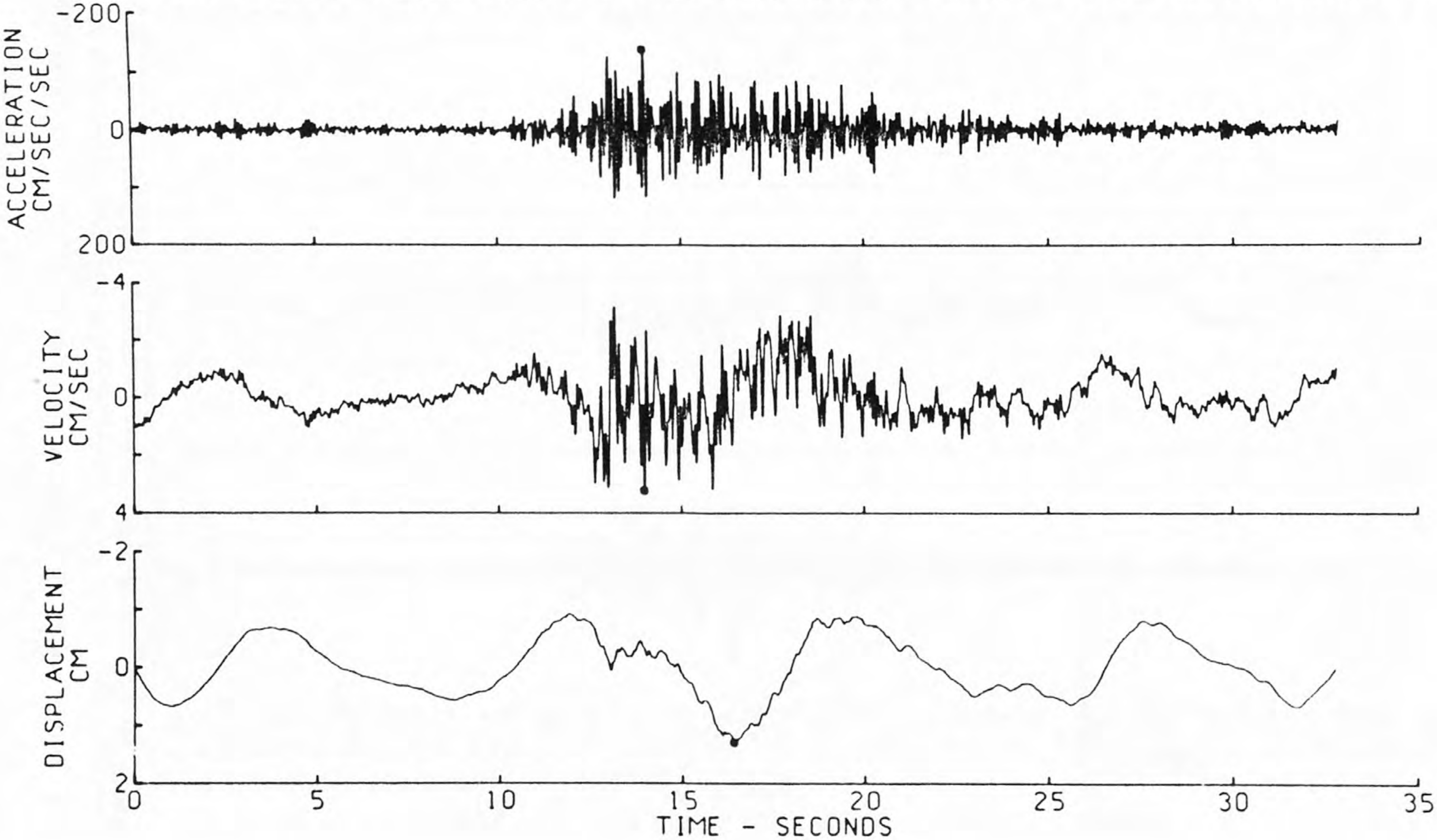

LIMA, PERU, ZARATE STATION, 1/5/74
V
L
T
ACCELERATION IN G/10
2
1
0
-1
-2
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
TIME IN SECONDS


LIMA, PERU, ZARATE STATION, 1/5/74
V
L
T
ACCELERATION IN G/10
2
0
-2
30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
TIME IN SECONDS

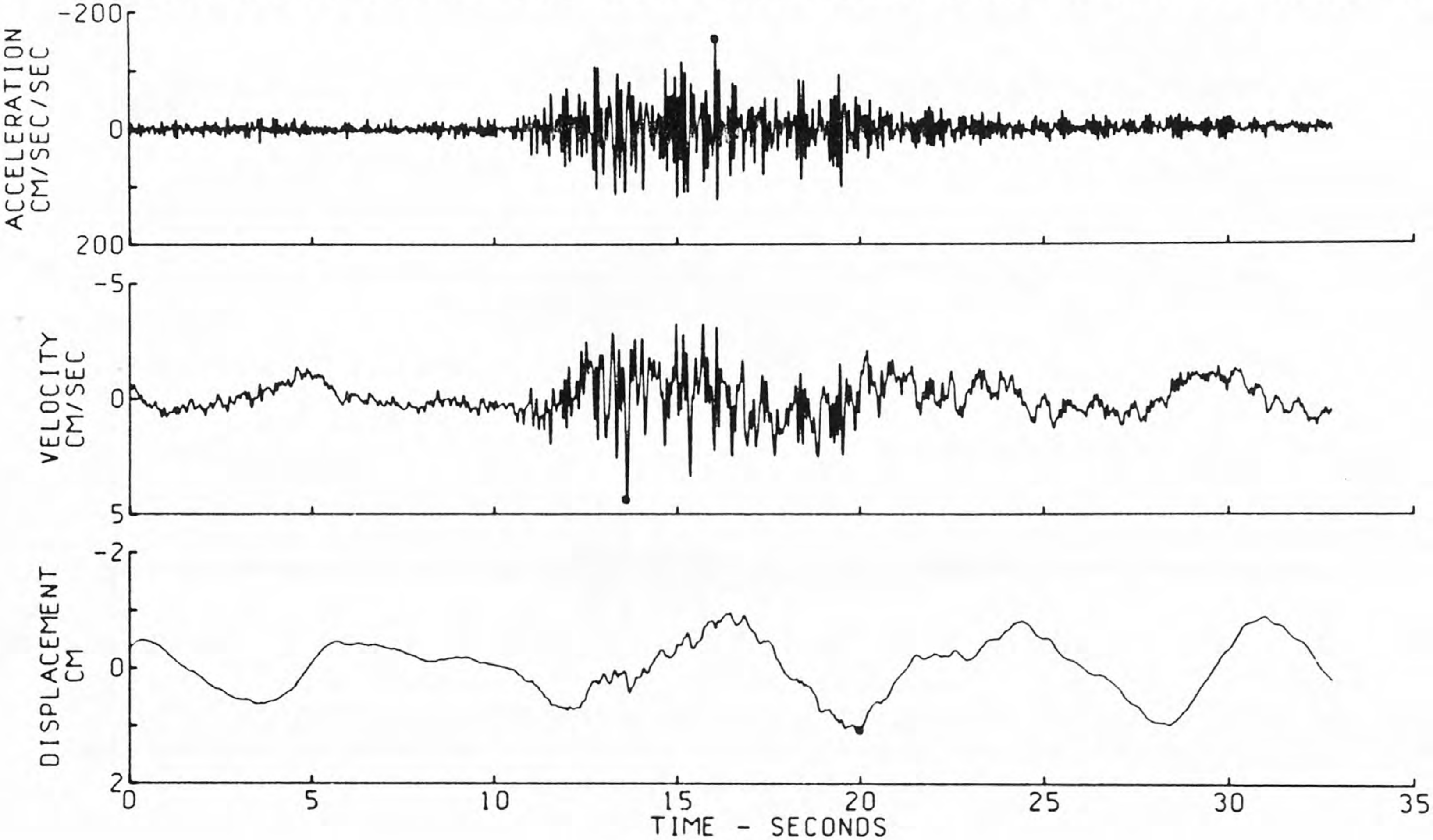
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF JANUARY 5, 1974
ZARATE STATION, V COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .090 - .125 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-77.10 CM/SEC/SEC, VELOCITY=-2.270 CM/SEC, DISPL=.760 CM

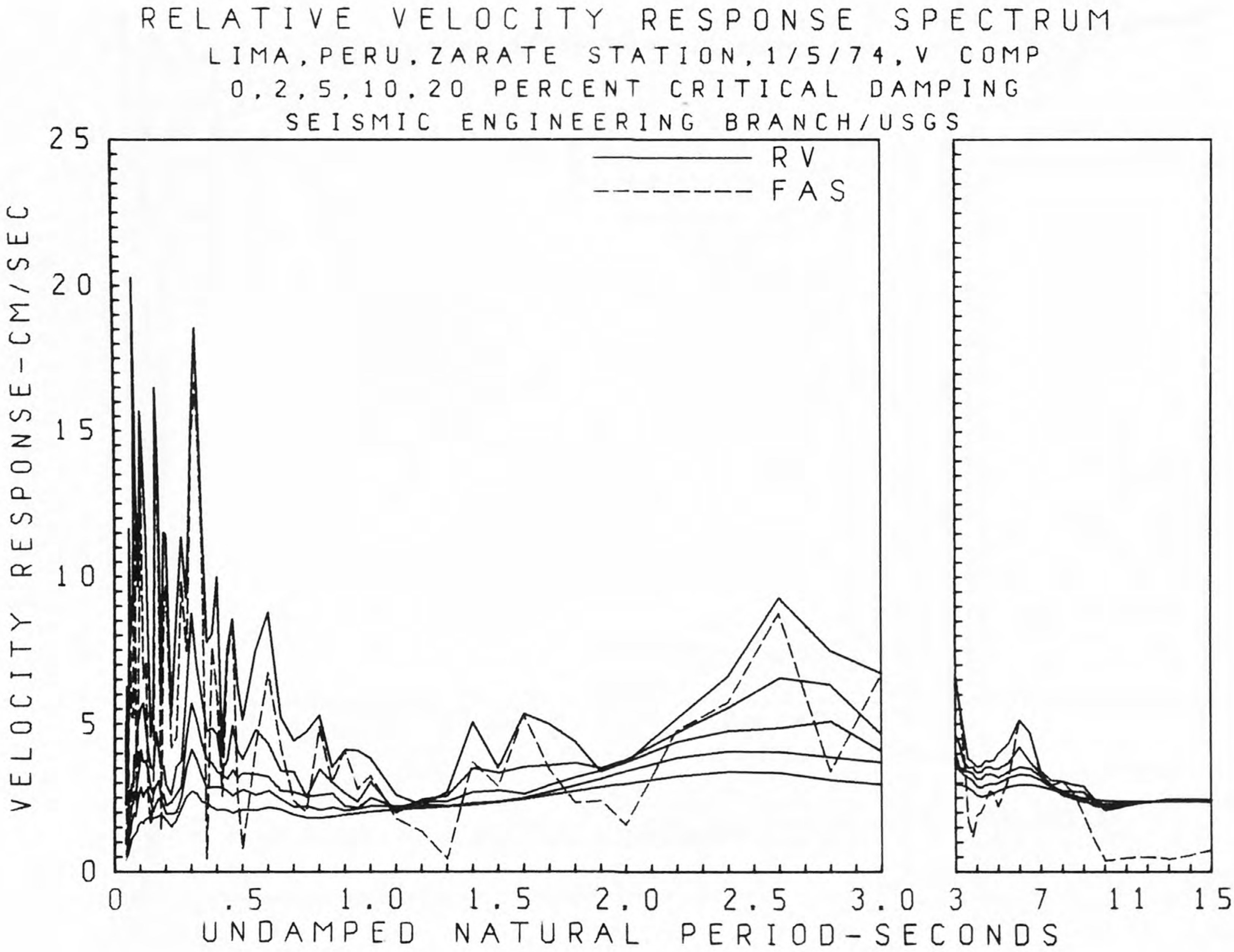


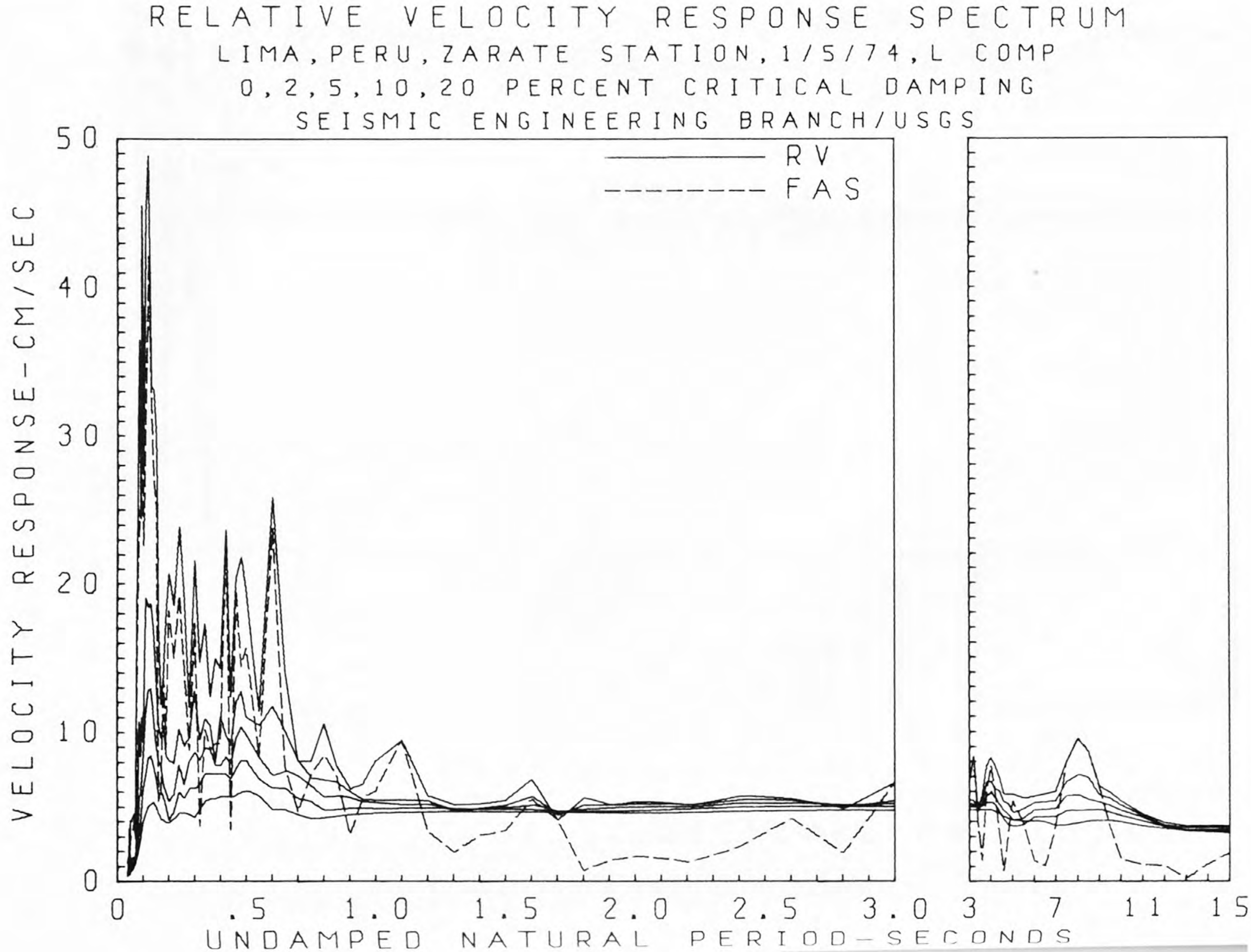
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHOUAKE OF JANUARY 5, 1974
ZARATE STATION, L COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .090 - .125 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-139.6 CM/SEC/SEC, VELOCITY=3.230 CM/SEC, DISPL=1.300 CM



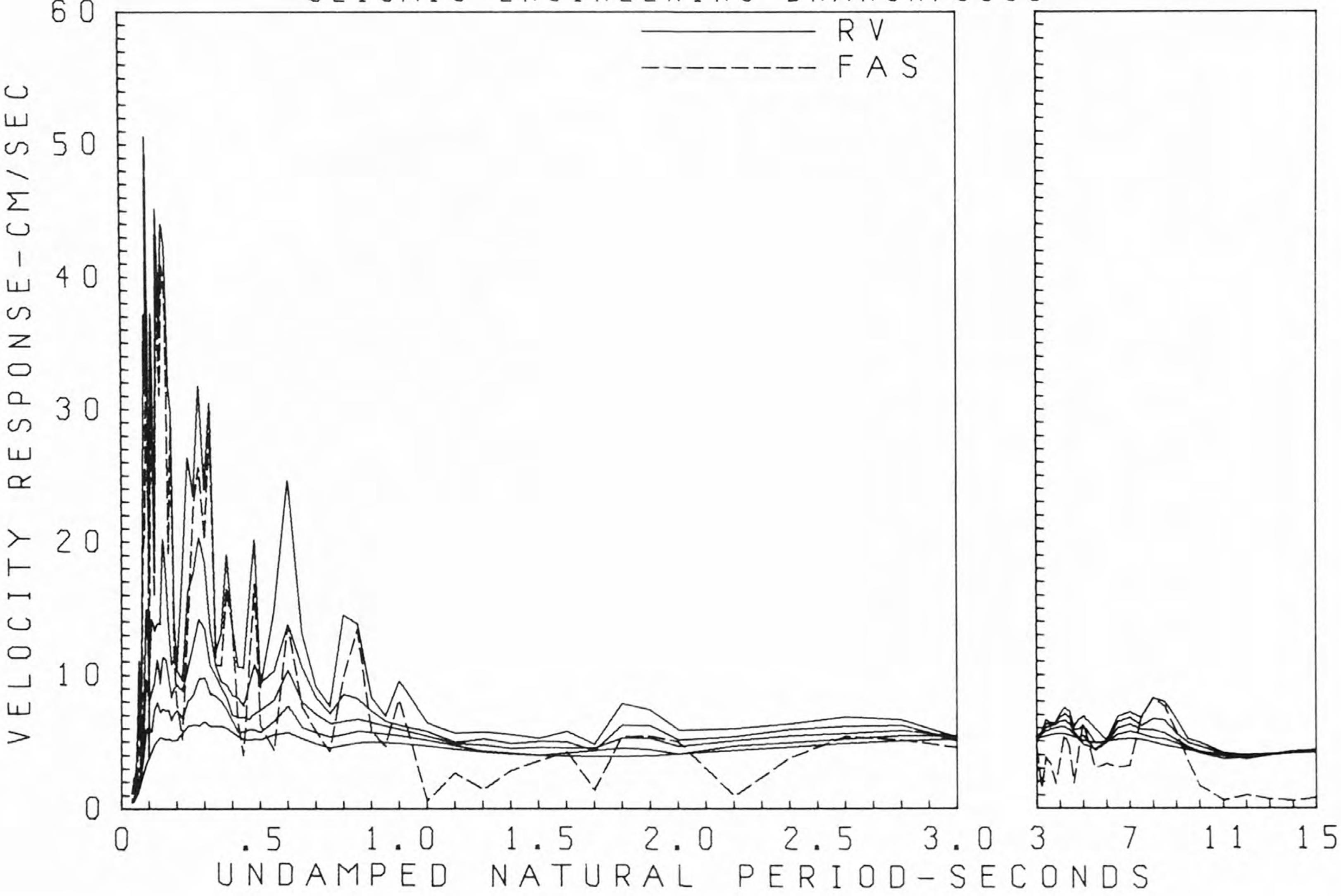
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF JANUARY 5, 1974
ZARATE STATION, T COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .090 - .125 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-156.2 CM/SEC/SEC, VELOCITY=4.400 CM/SEC, DISPL=1.080 CM

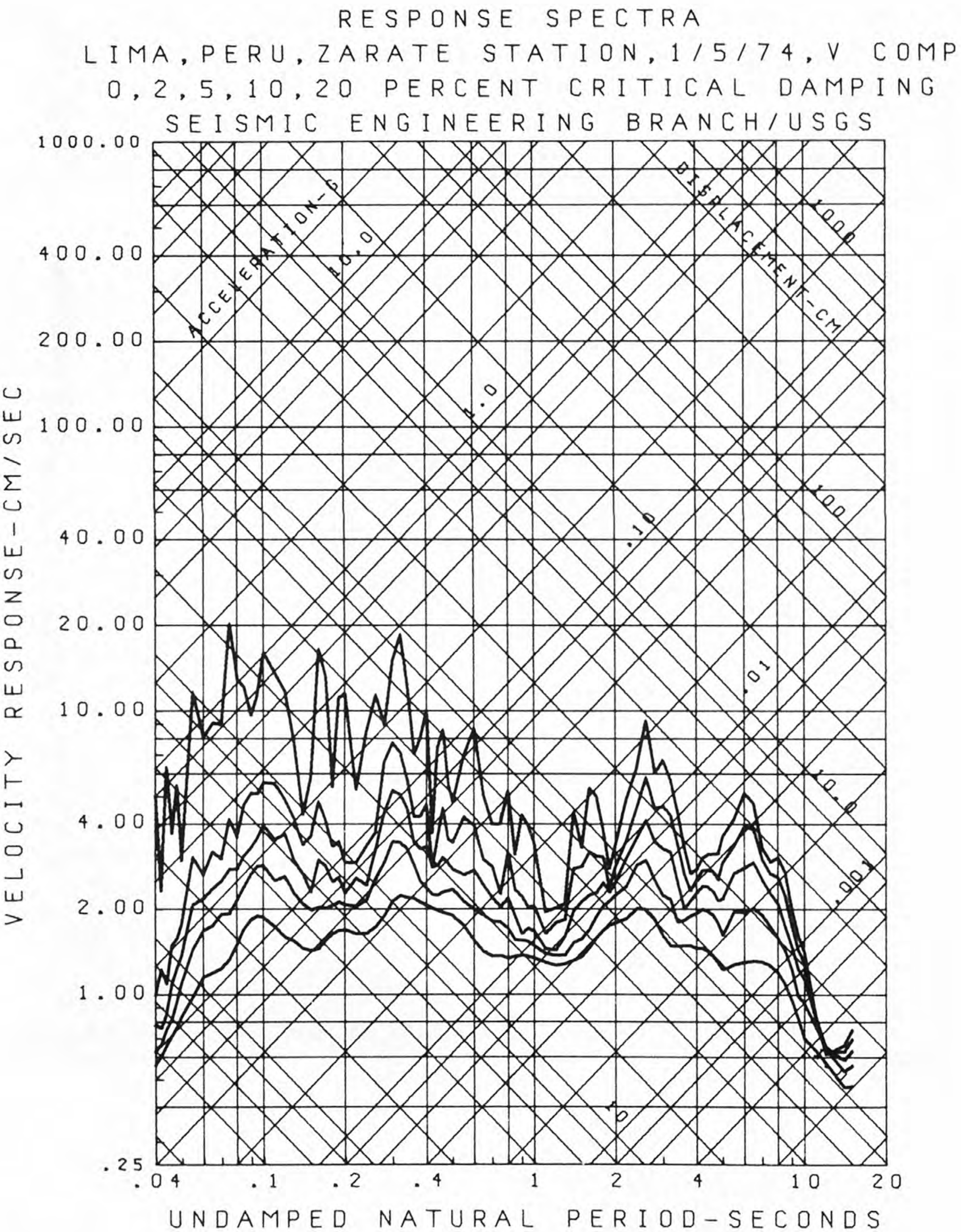



RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, ZARATE STATION, 1/5/74, V COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
0
5
10
15
20
25
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

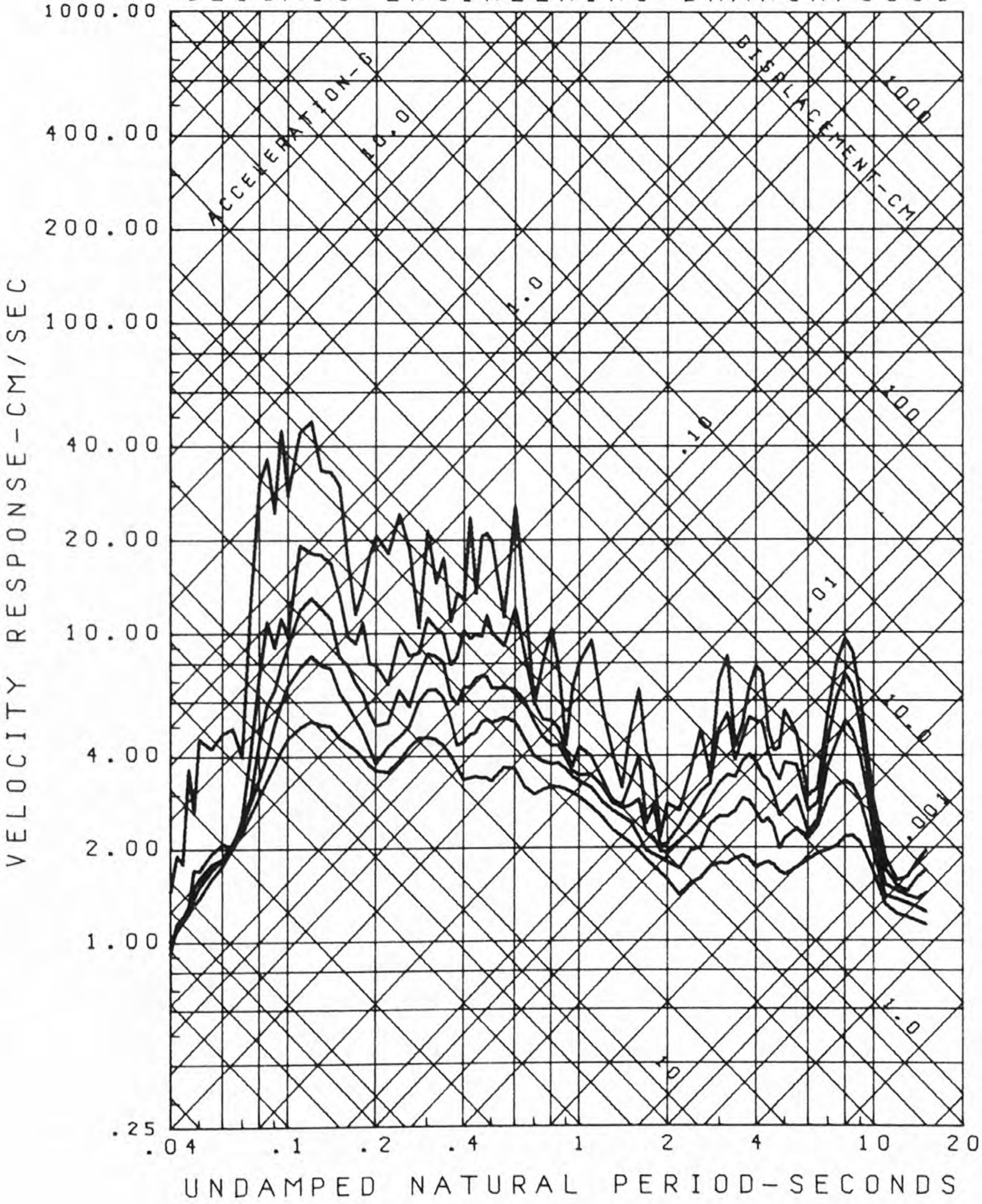

RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, ZARATE STATION, 1/5/74, L COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
0
10
20
30
40
50
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, ZARATE STATION, 1/5/74, T COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

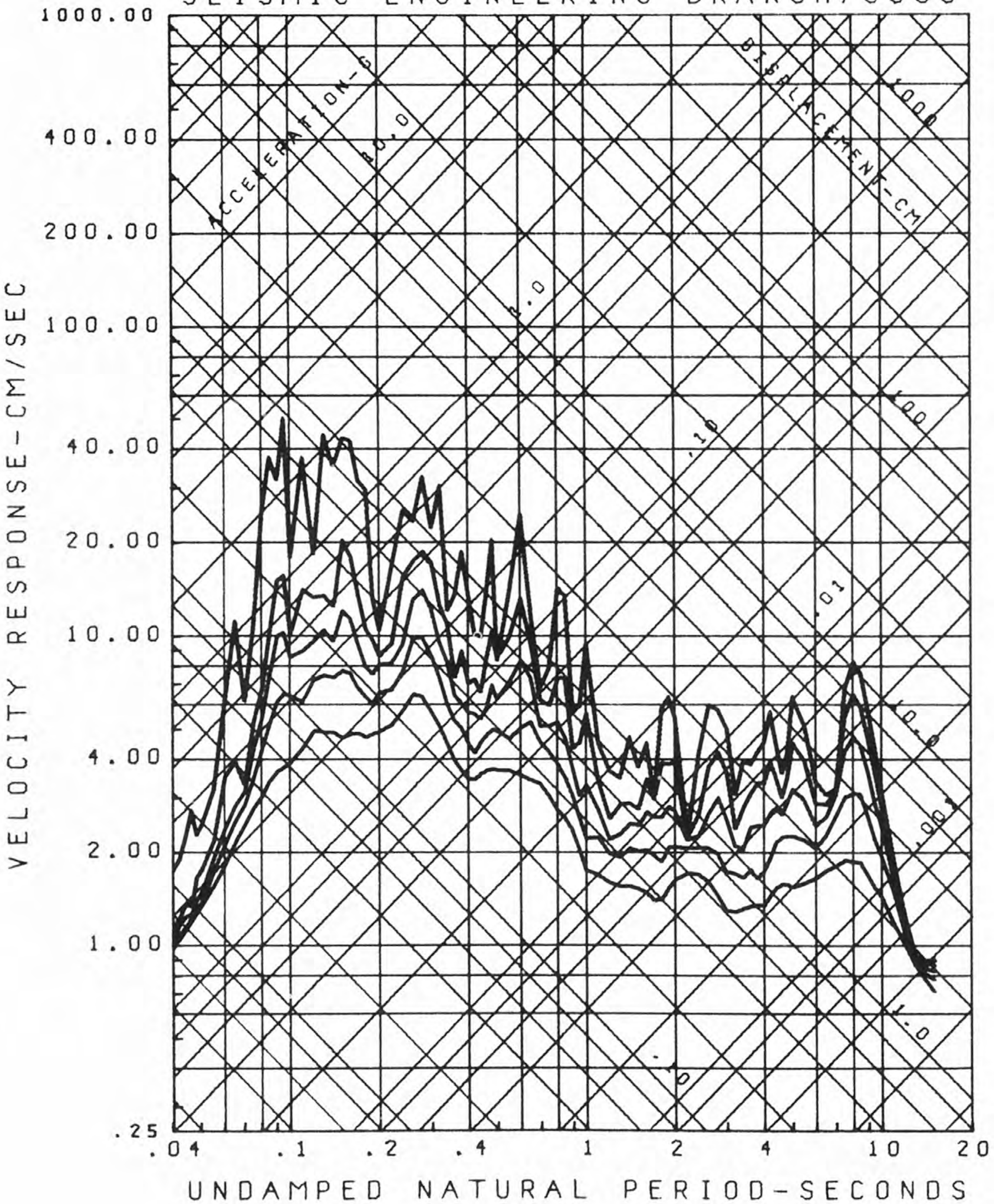


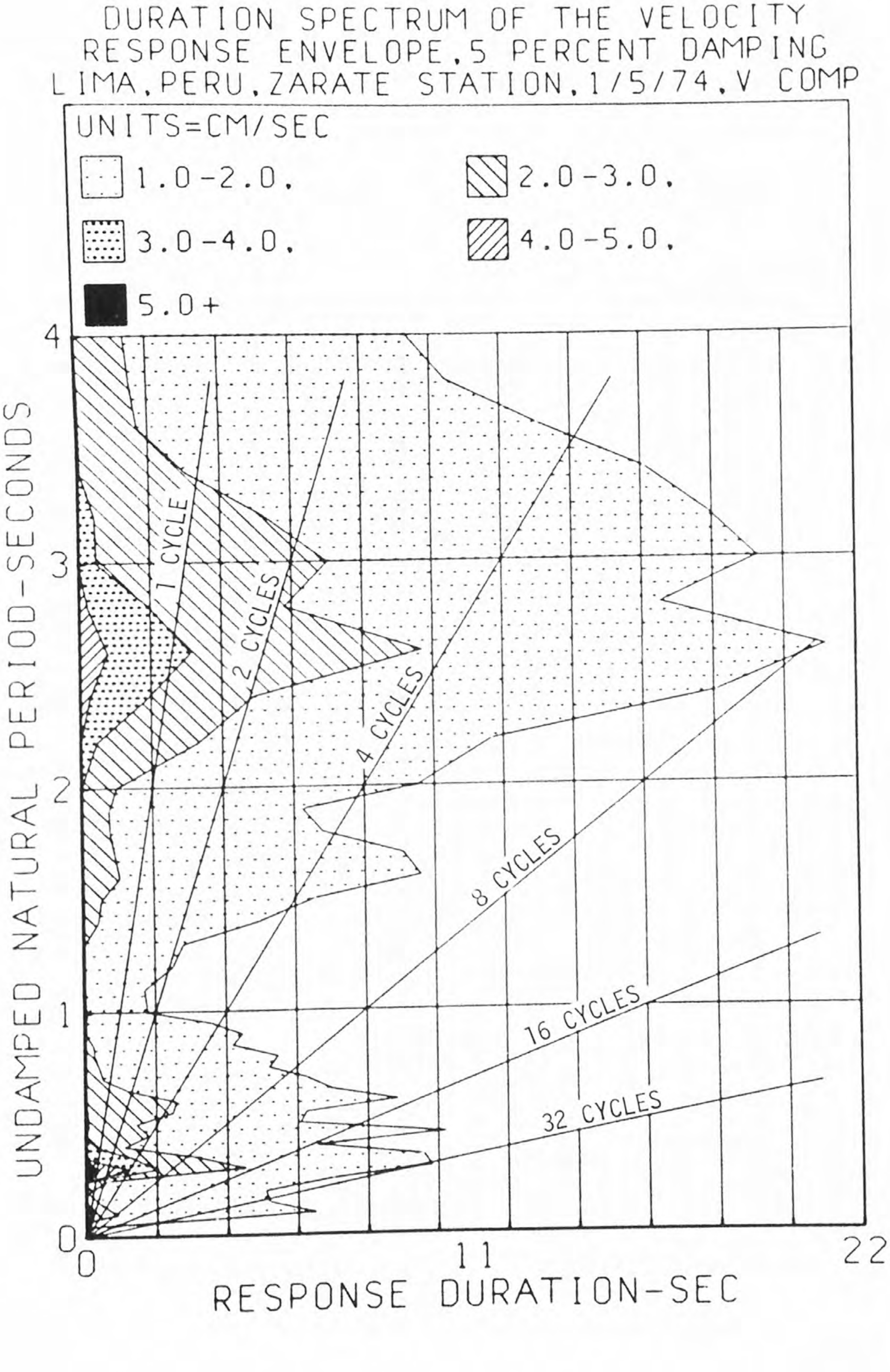

RESPONSE SPECTRA
LIMA, PERU, ZARATE STATION, 1/5/74, V COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
10.0
1.0
.10
.01
1000
100
10.0
.001
1.0

RESPONSE SPECTRA
LIMA, PERU, ZARATE STATION, 1/5/74, L COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

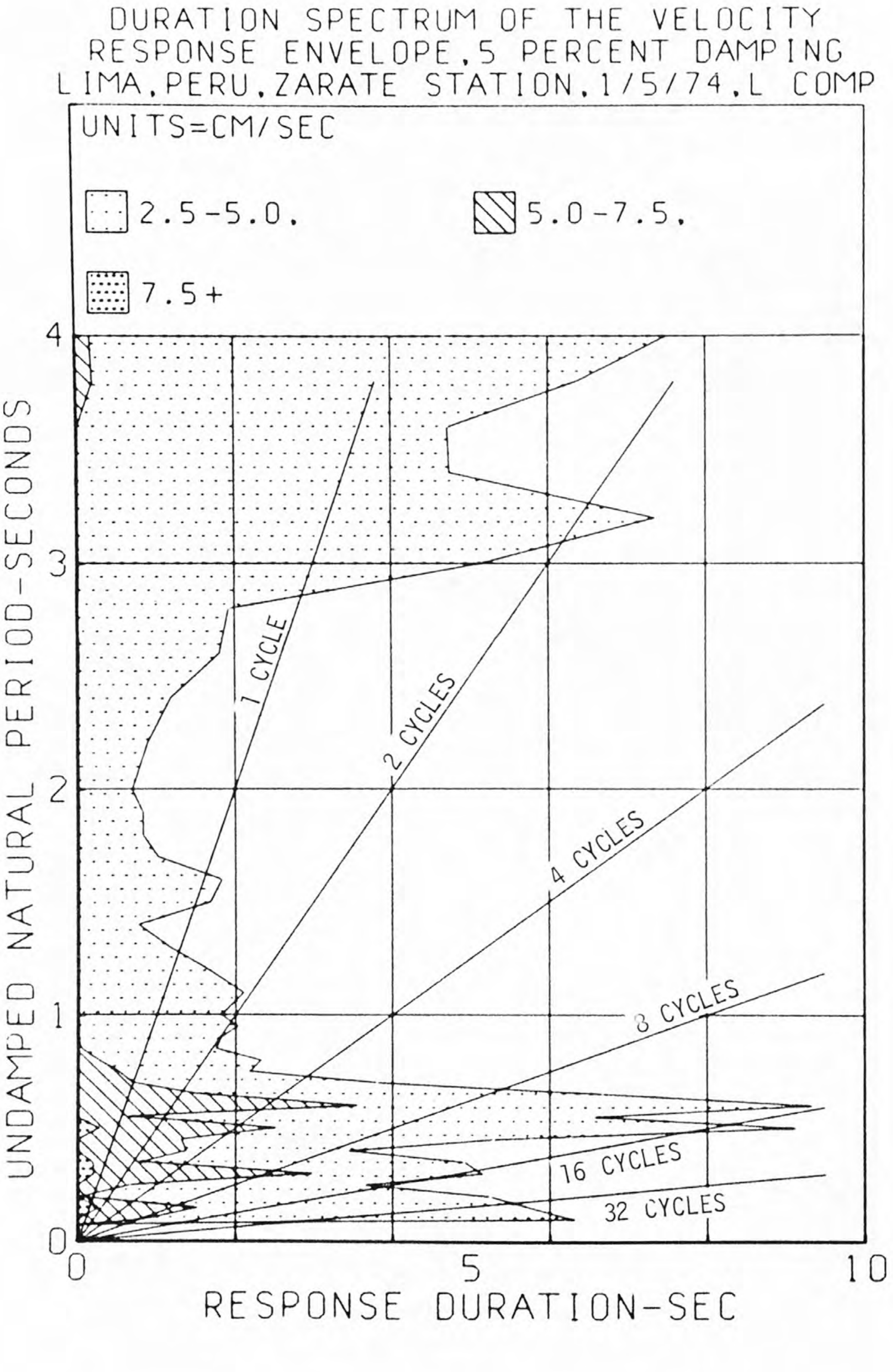


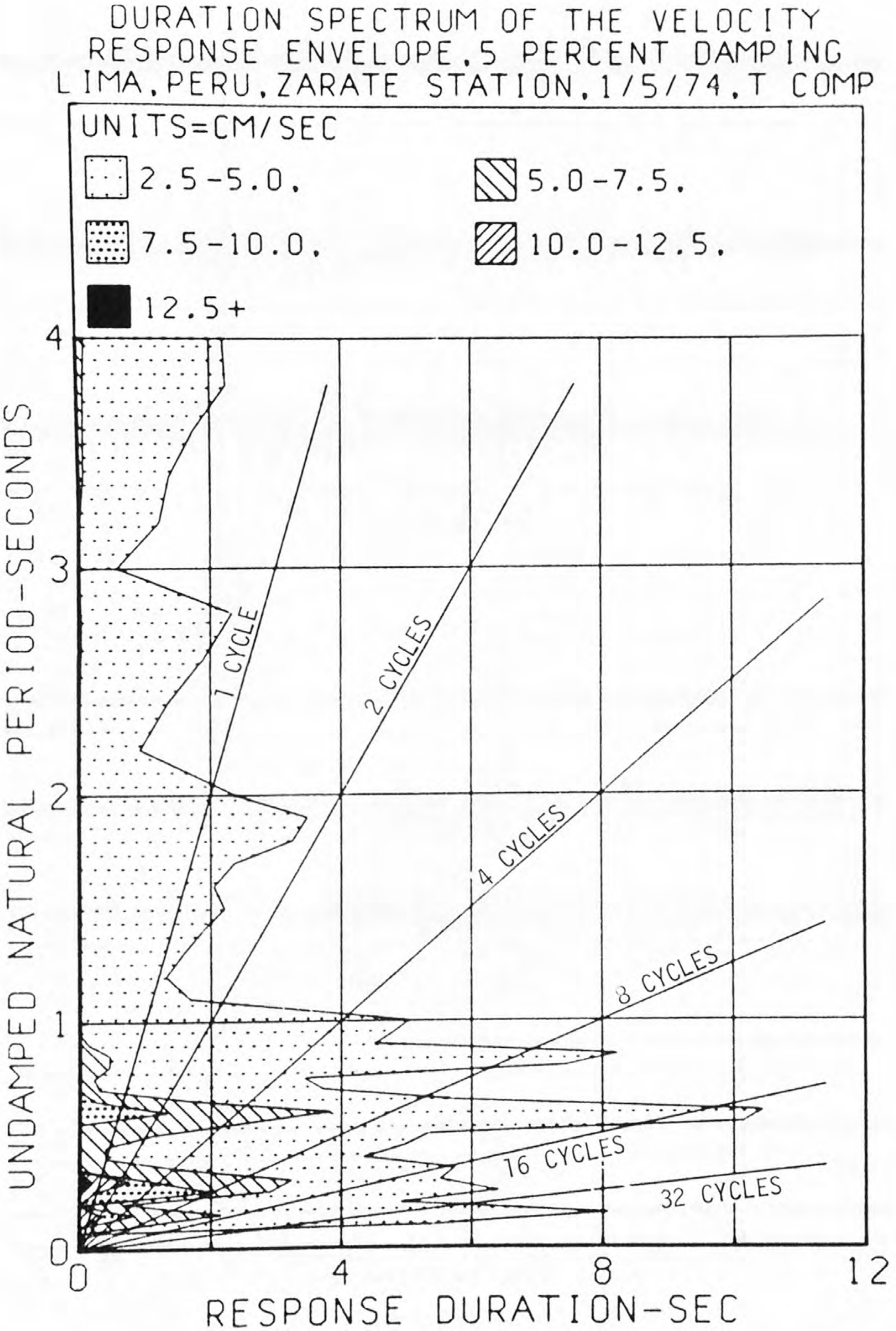
RESPONSE SPECTRA
LIMA, PERU, ZARATE STATION, 1/5/74, T COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS



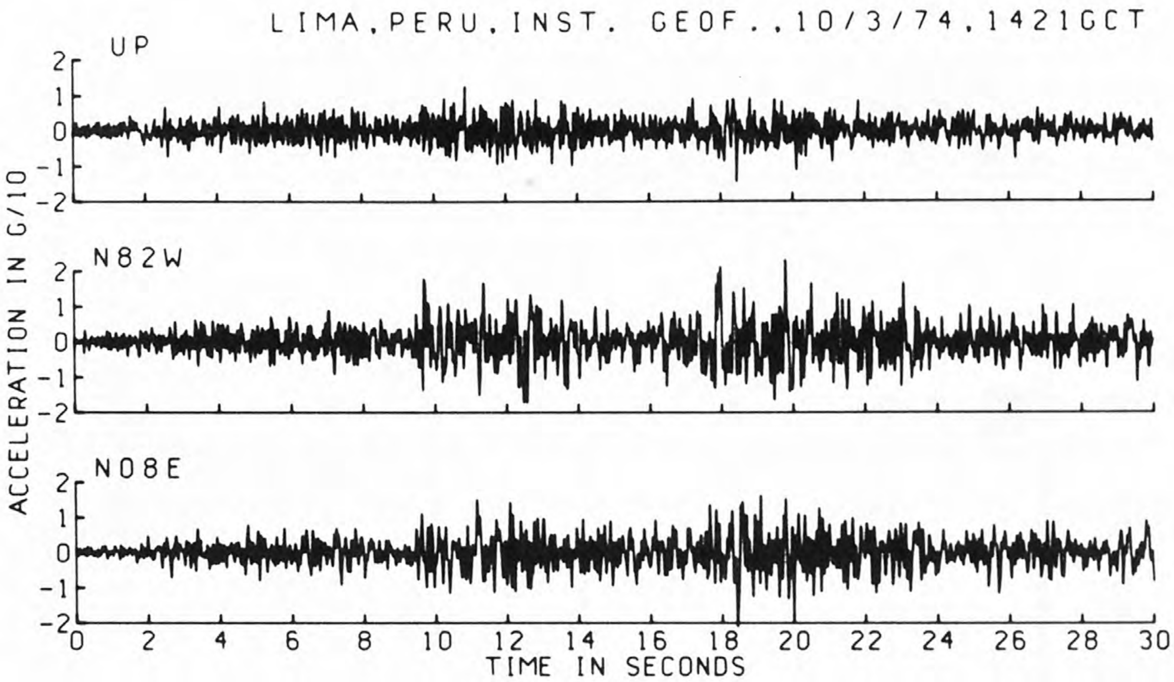


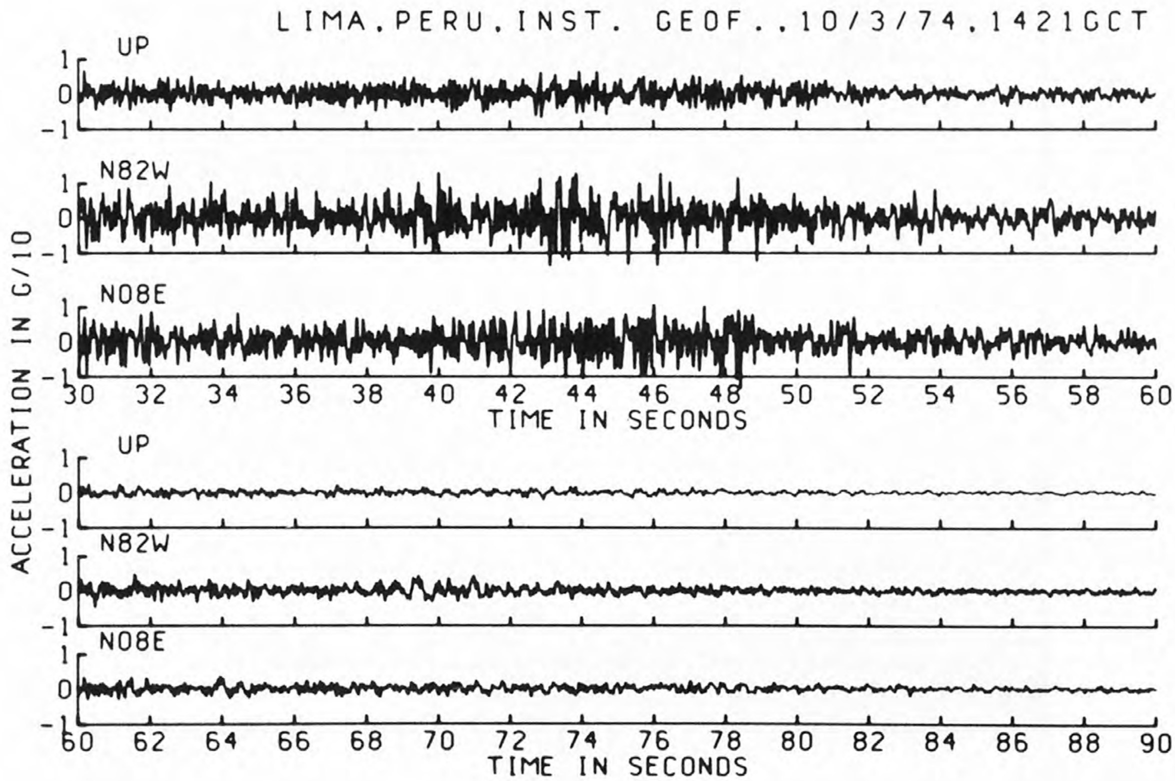
DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, ZARATE STATION, 1/5/74, V COMP
UNITS=CM/SEC
1.0-2.0.
2.0-3.0.
3.0-4.0.
4.0-5.0.
5.0+
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
0
11
22
1
2
3
4
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES


DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, ZARATE STATION, 1/5/74, L COMP
UNITS=CM/SEC
2.5-5.0,
5.0-7.5,
7.5+
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
0
1
2
3
4
5
10

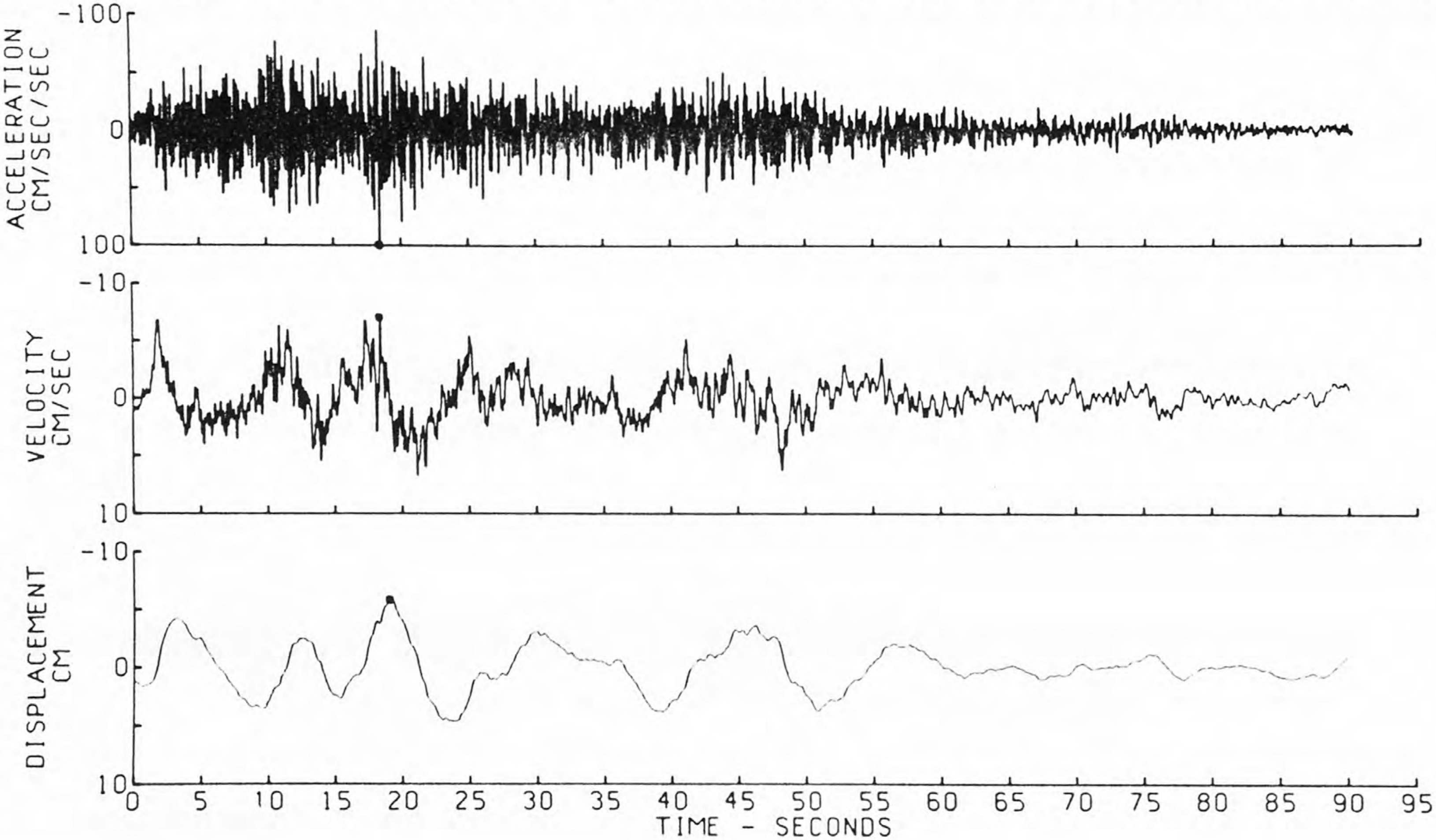


DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, ZARATE STATION, 1/5/74, T COMP
UNITS=CM/SEC
2.5-5.0,
5.0-7.5,
7.5-10.0,
10.0-12.5,
12.5+
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
0
1
2
3
4
0
4
8
12

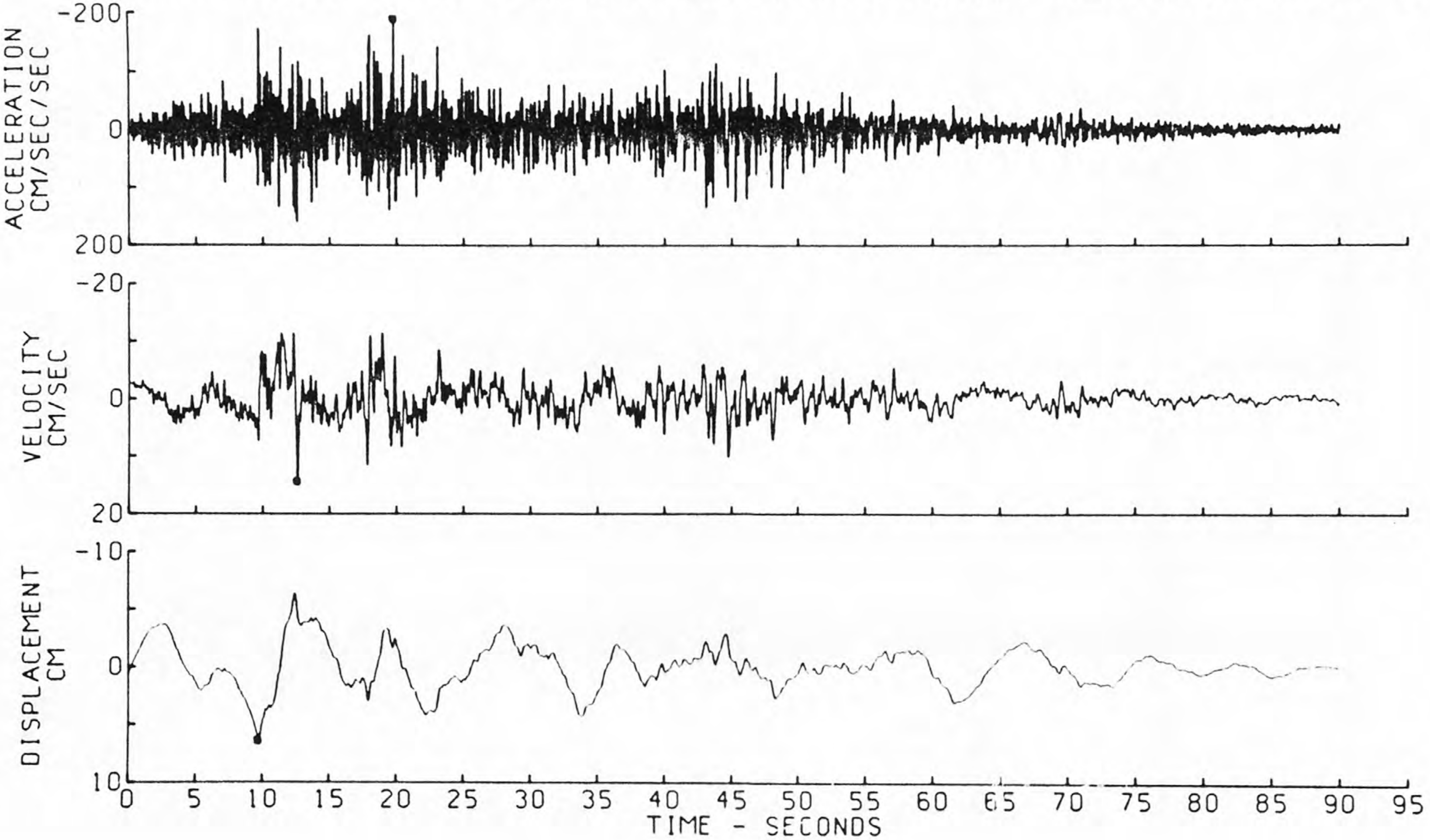

LIMA, PERU, INST. GEOF., 10/3/74, 1421GCT
UP
N82W
N08E
ACCELERATION IN G/10
TIME IN SECONDS


LIMA, PERU, INST. GEOF., 10/3/74, 1421GCT
UP
N82W
N08E
ACCELERATION IN G/10
TIME IN SECONDS

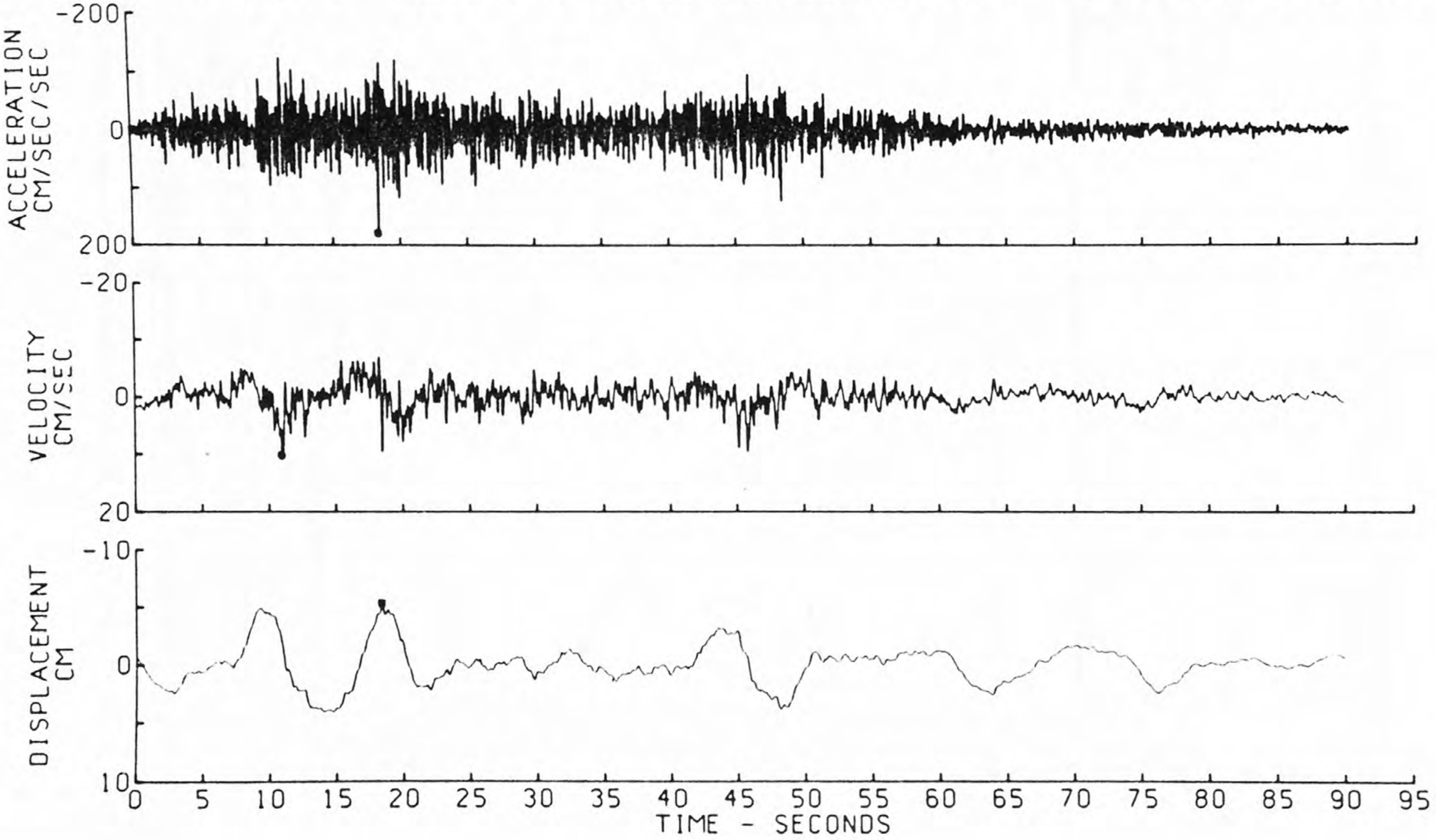
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF OCOTBER 3, 1974 - 1421 GCT
INSTITUTO GEOFISICO DEL PERU, UP COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .050 - .070 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=99.75 CM/SEC/SEC, VELOCITY=-7.030 CM/SEC, DISPL=-5.810 CM



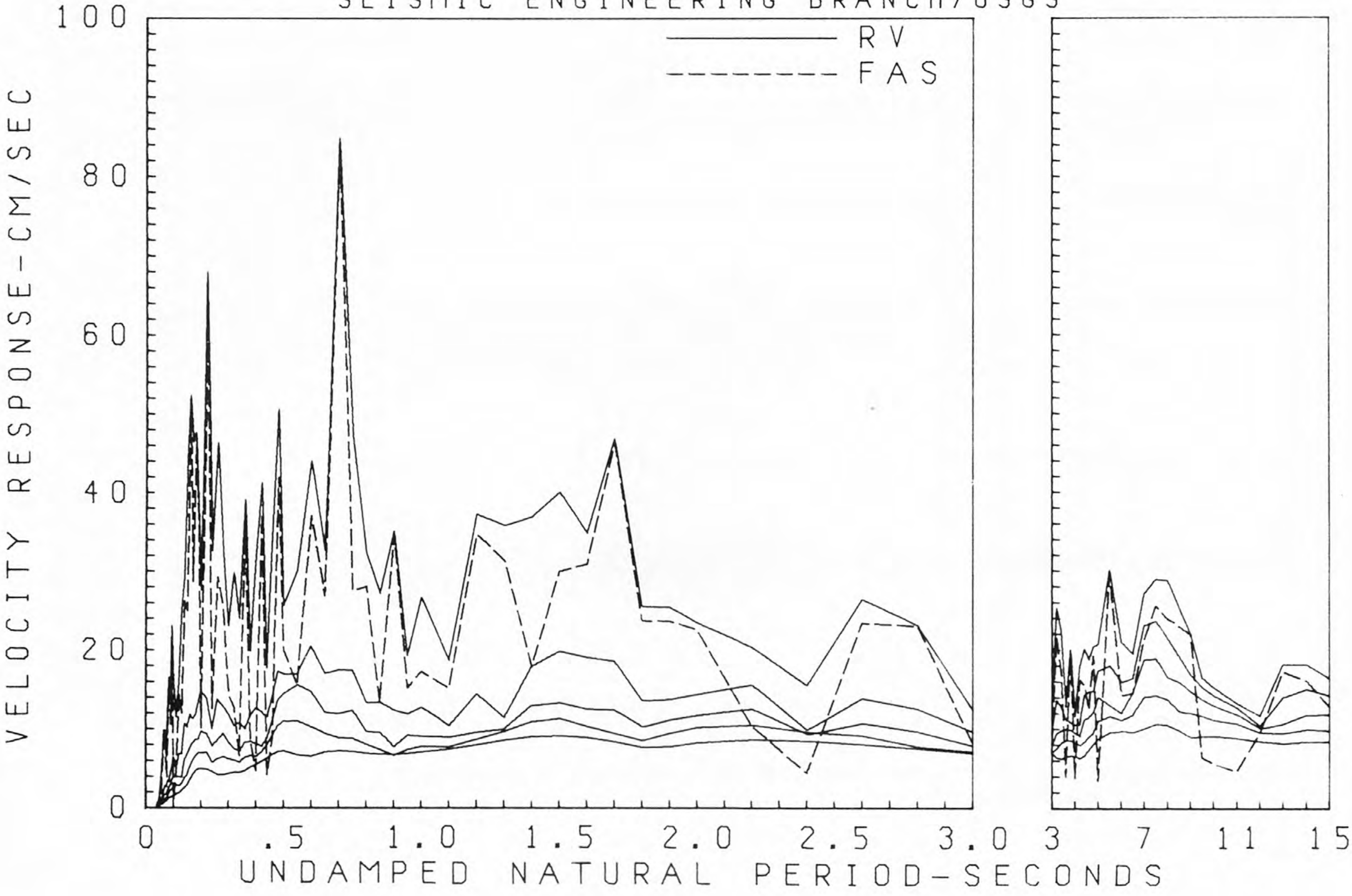
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF OCTOBER 3, 1974 - 1421 GCT
INSTITUTO GEOFISICO DEL PERU, N82W COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .050 - .070 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-192.5 CM/SEC/SEC, VELOCITY=14.48 CM/SEC, DISPL=6.410 CM

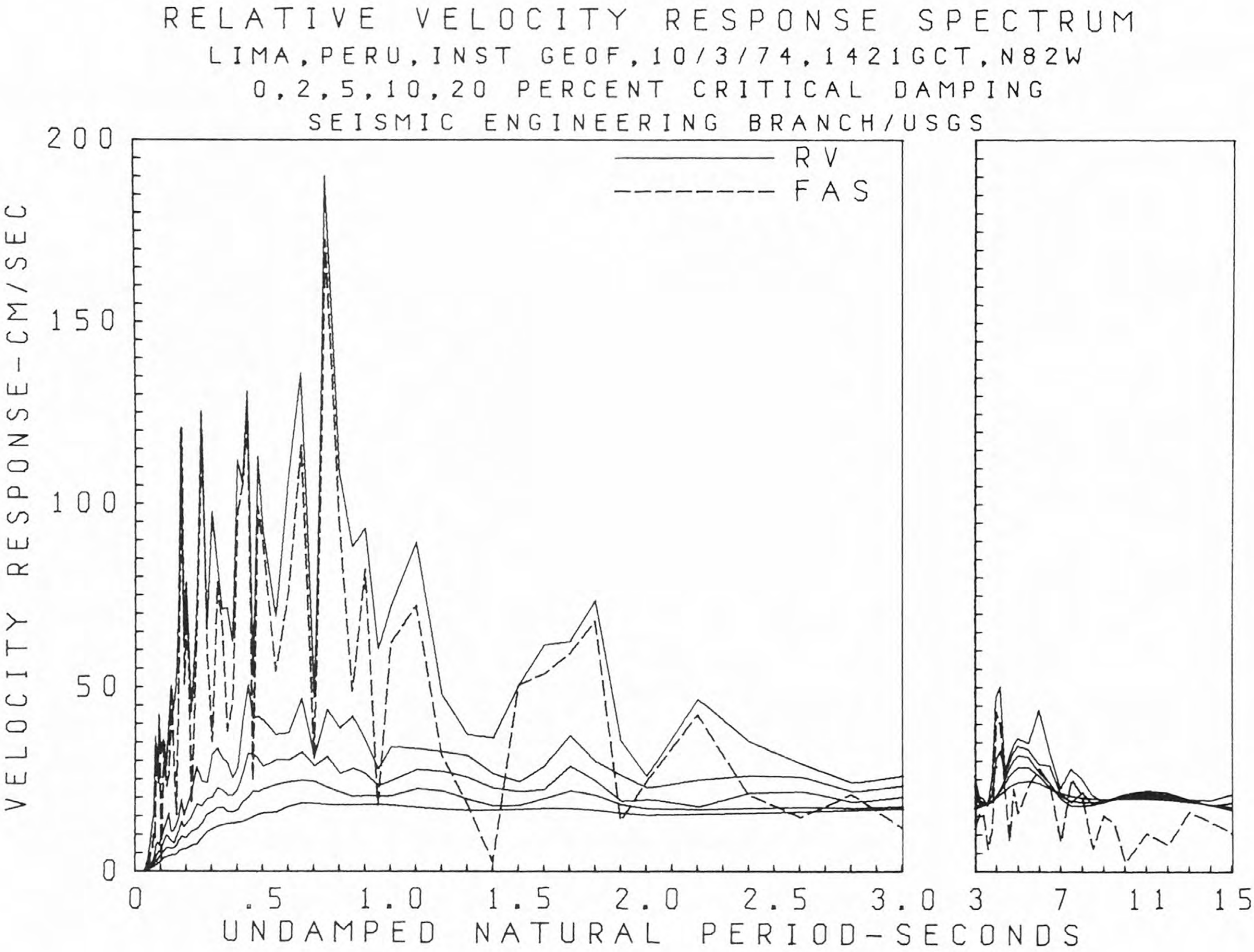


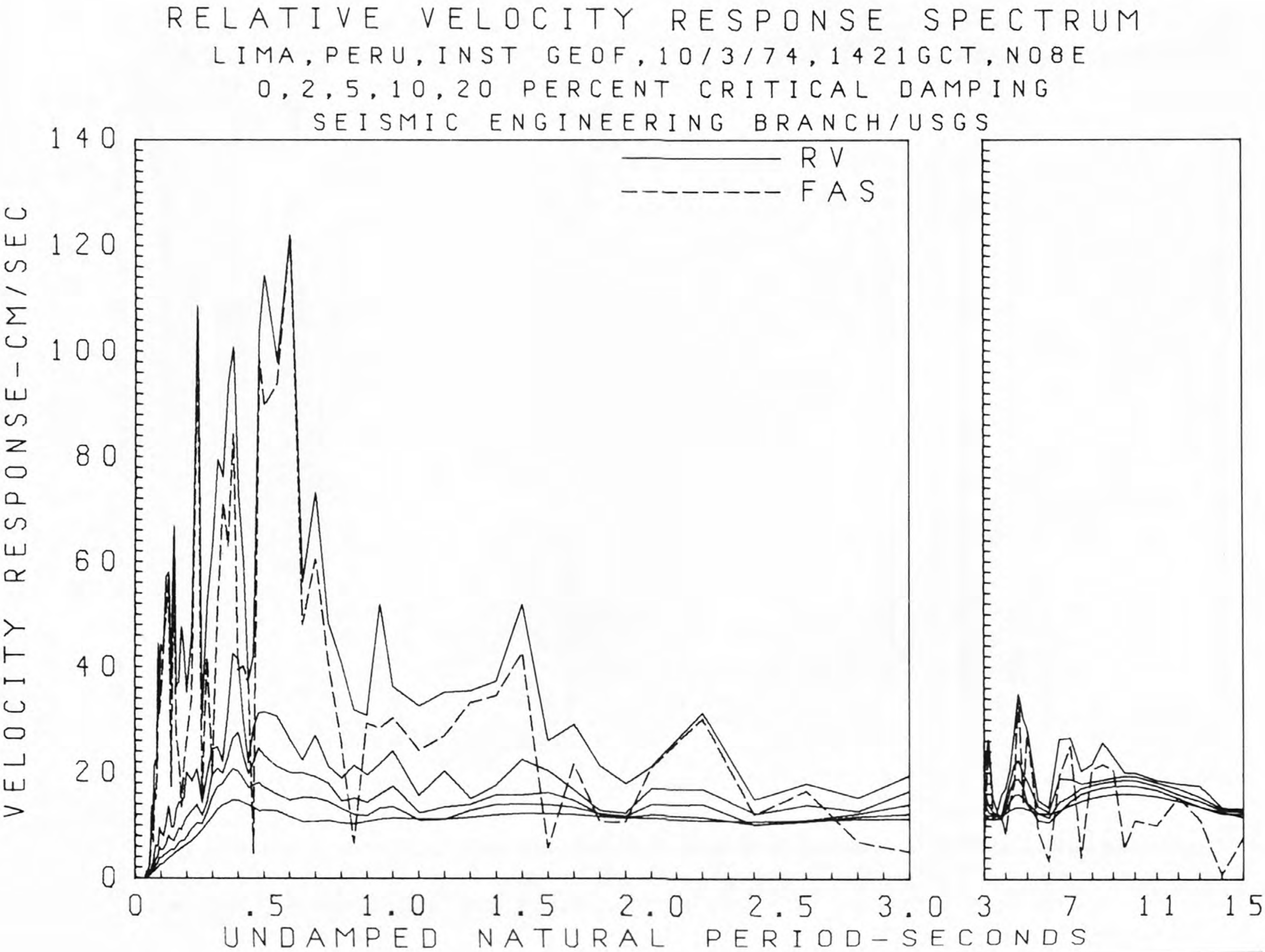
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF OCOTBER 3, 1974 - 1421 GCT
INSTITUTO GEOFISICO DEL PERU, N08E COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .050 - .070 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=178.9 CM/SEC/SEC, VELOCITY=10.30 CM/SEC, DISPL=-5.340 CM



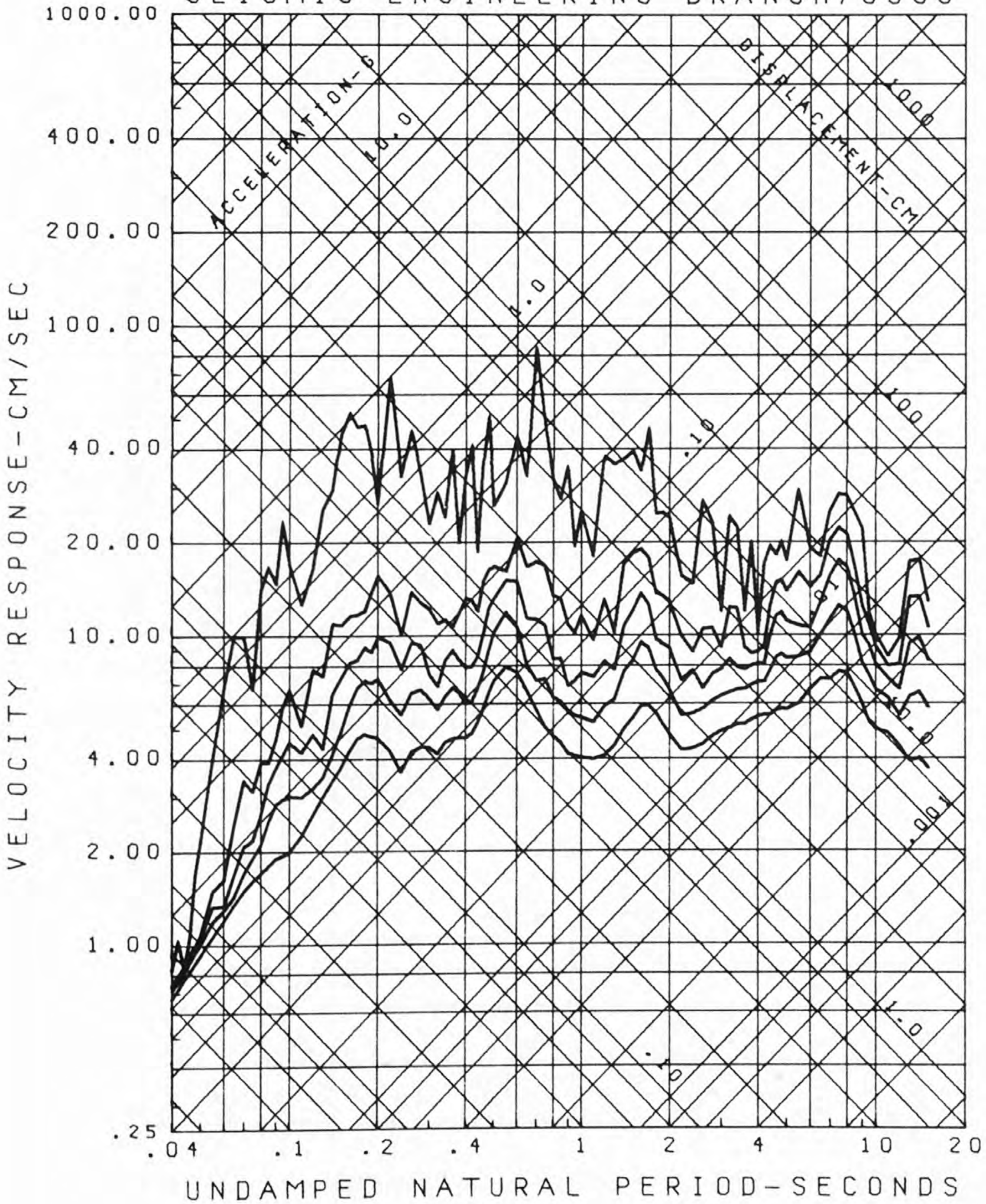
RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST GEOF, 10/3/74, 1421GCT, UP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

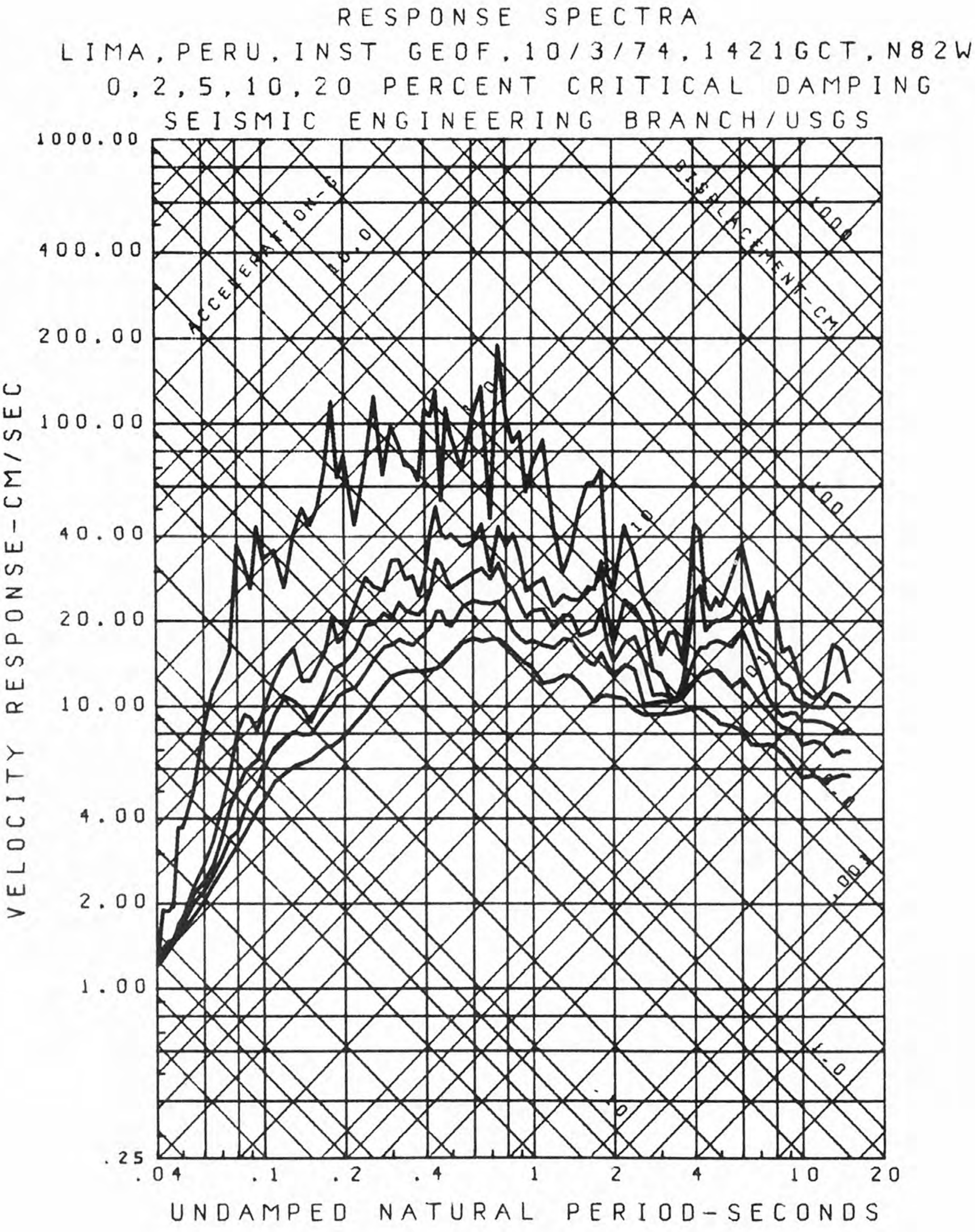


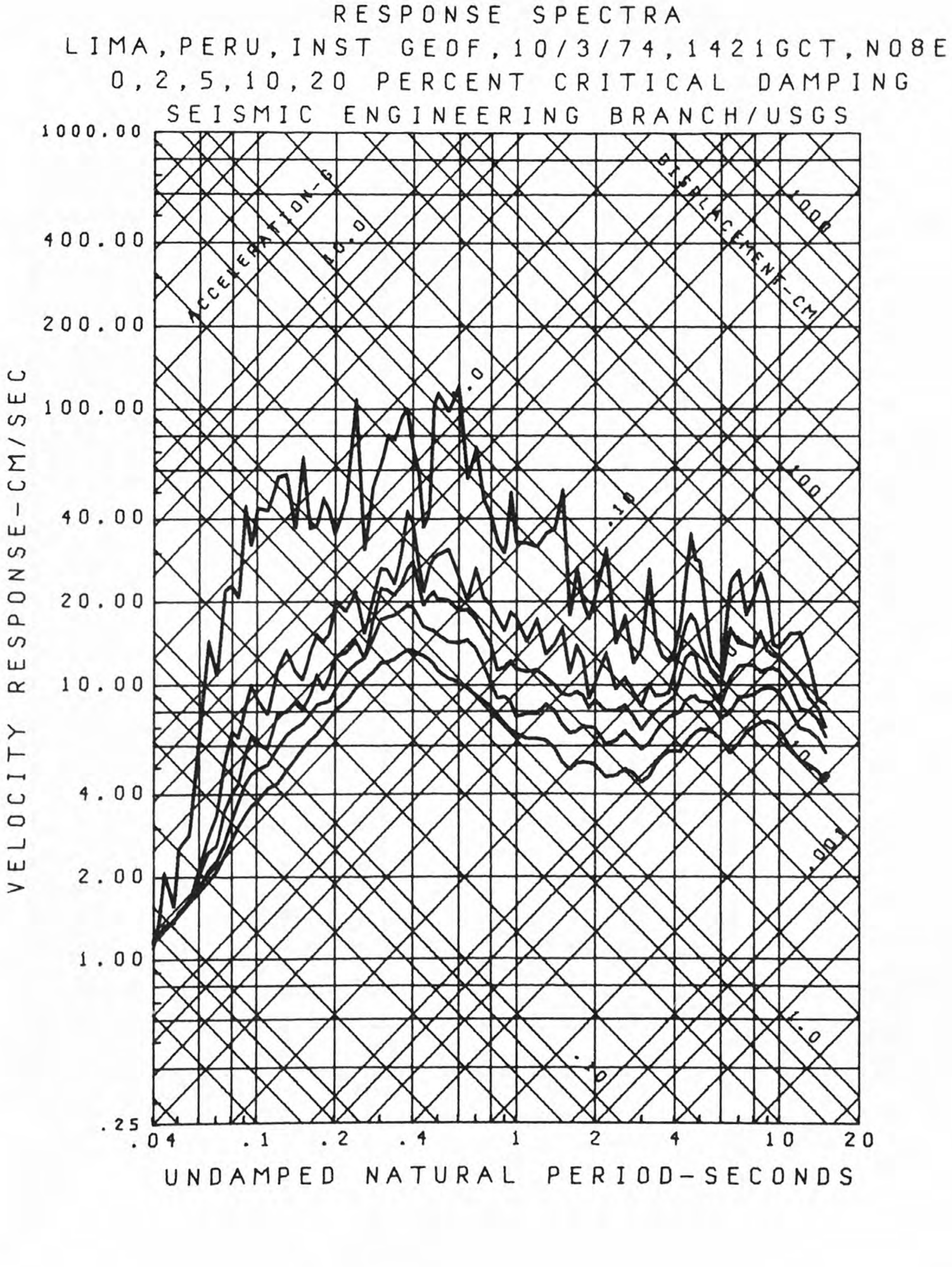

RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA,PERU,INST GEOF,10/3/74,1421GCT,N82W
0,2,5,10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
0
50
100
150
200
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

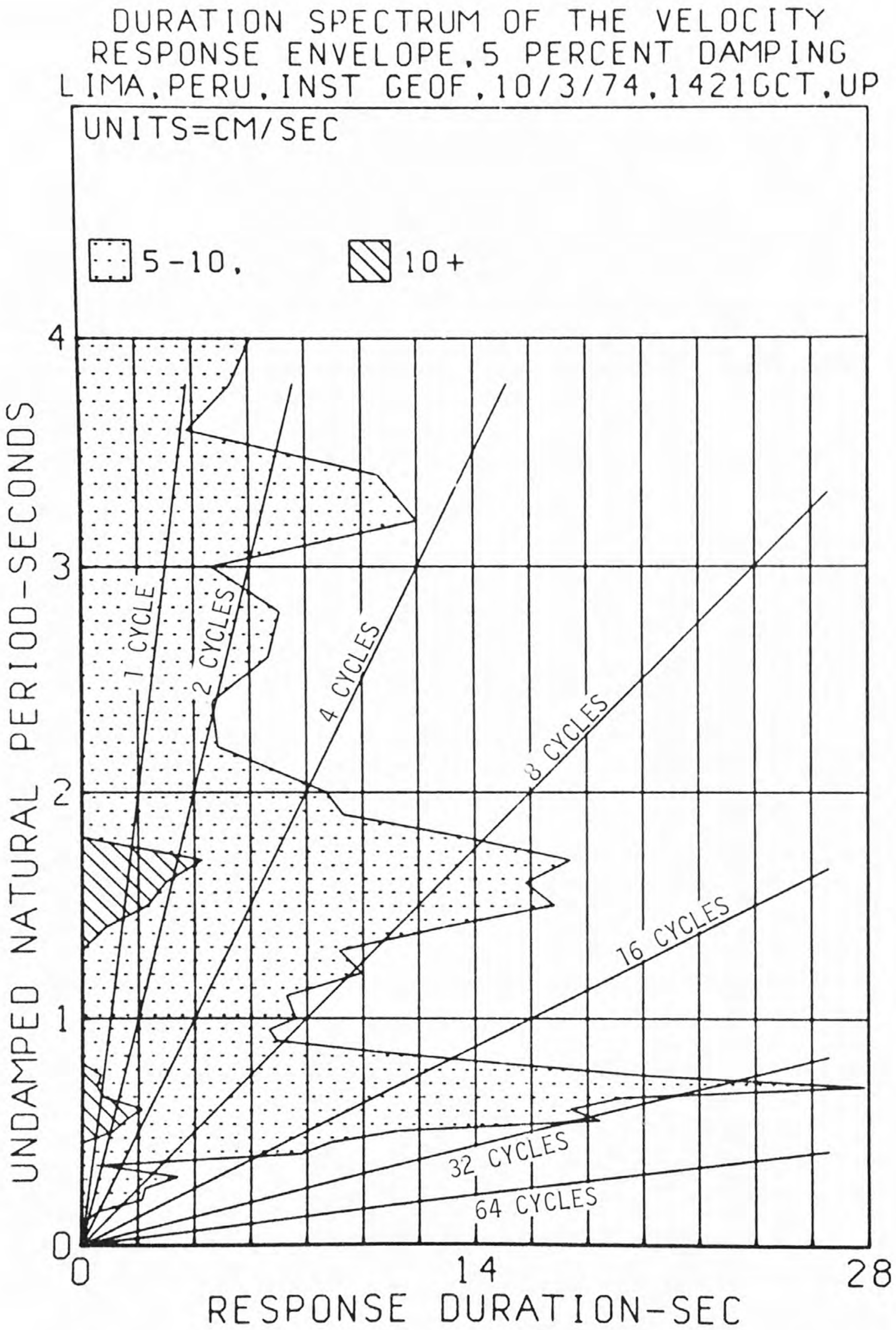

RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST GEOF, 10/3/74, 1421GCT, N08E
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
0
20
40
60
80
100
120
140
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

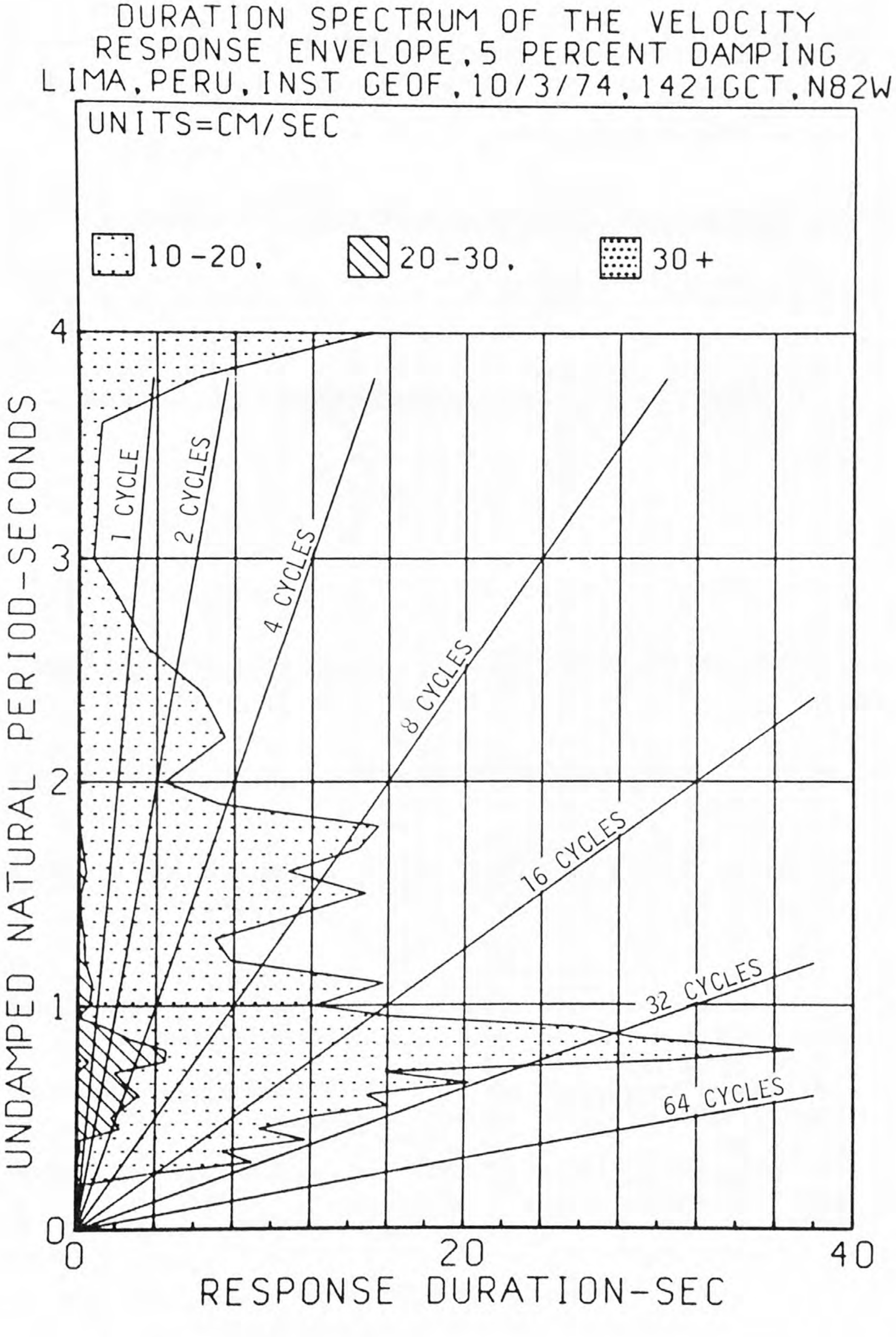
RESPONSE SPECTRA
LIMA, PERU, INST GEOF, 10/3/74, 1421GCT, UP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

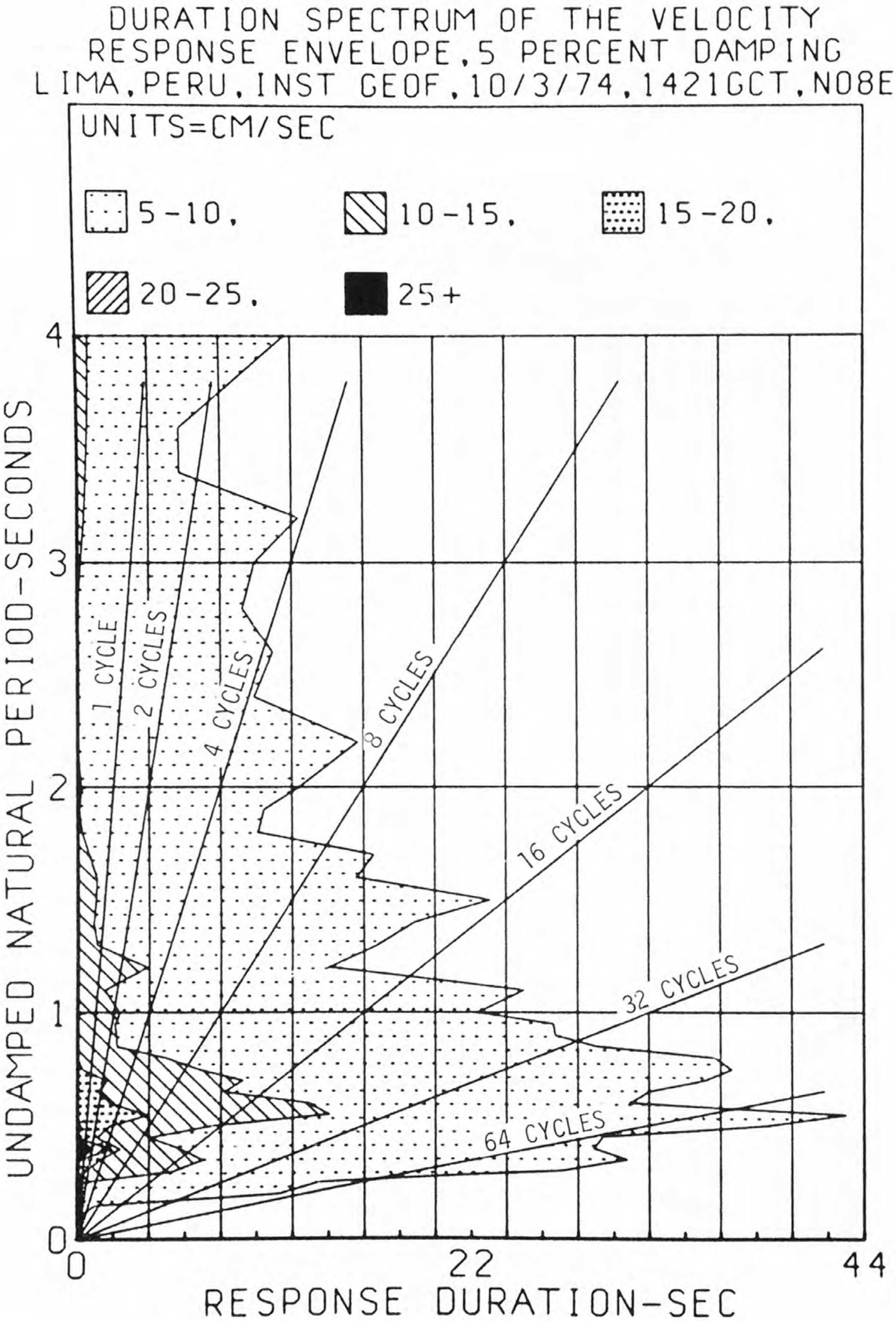


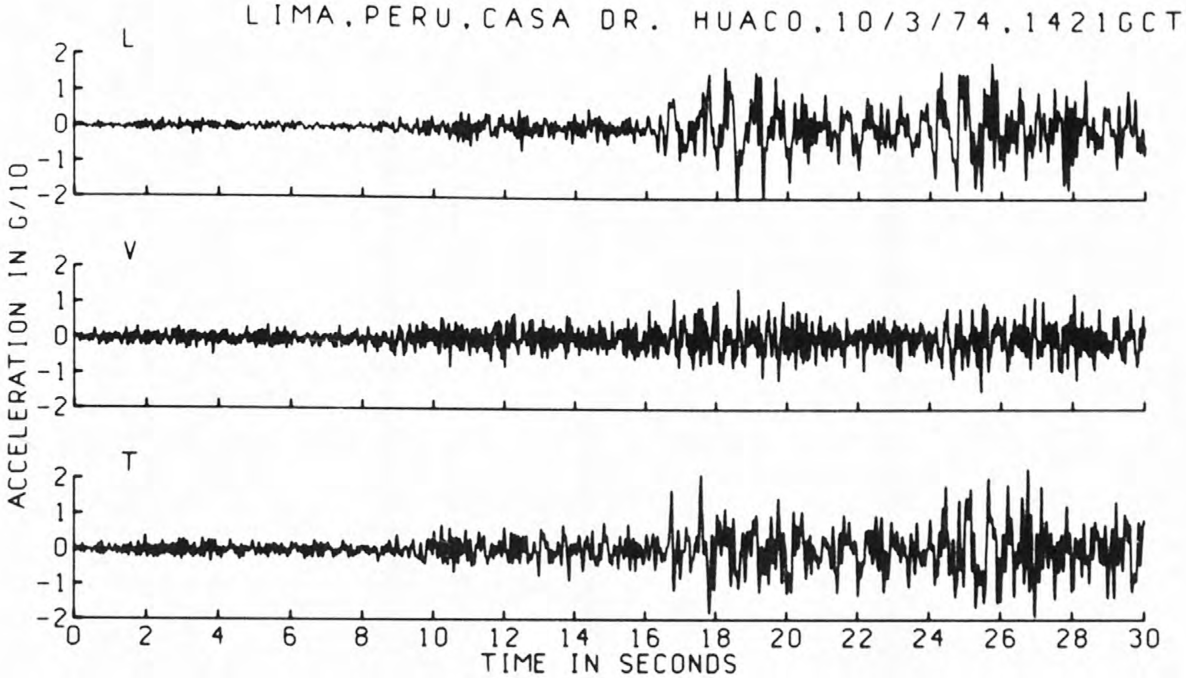

RESPONSE SPECTRA
LIMA, PERU, INST GEOF, 10/3/74, 1421GCT, N82W
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
1000
100
10

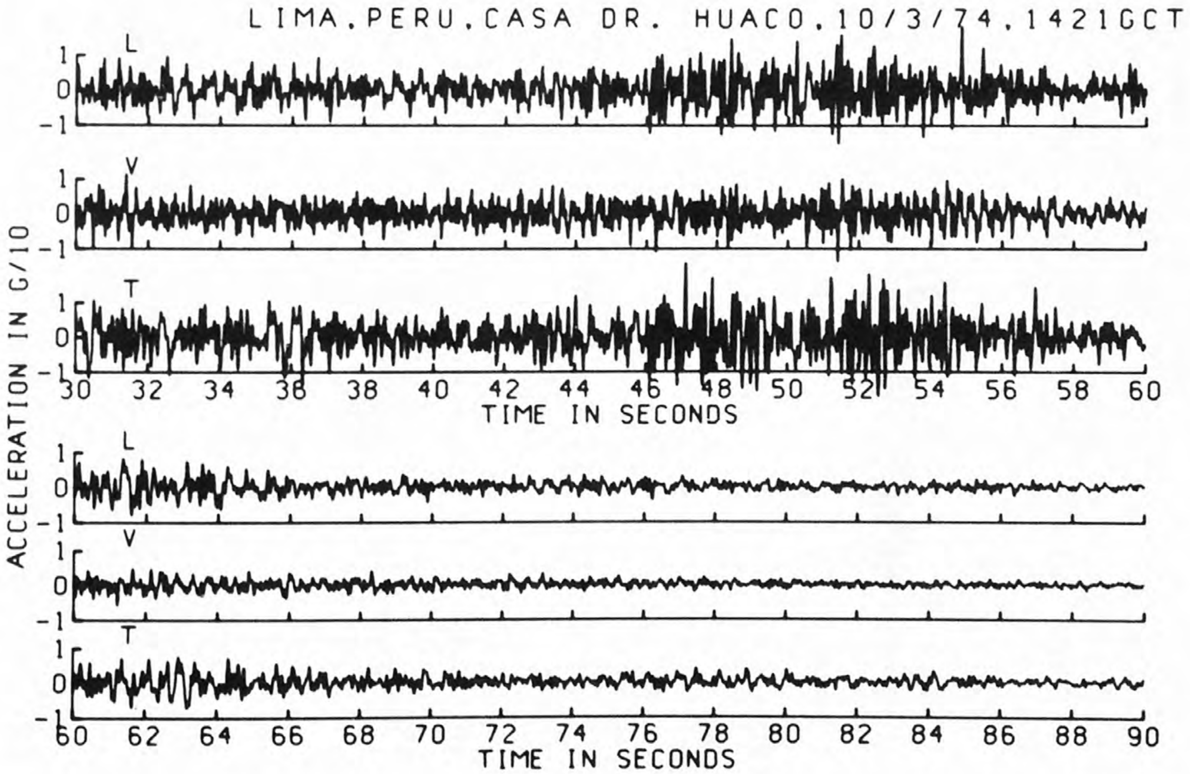

RESPONSE SPECTRA
LIMA, PERU, INST GEOF, 10/3/74, 1421GCT, N08E
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
ACCELERATION-G
10.0
1.0
.10
.01
DISPLACEMENT-CM
1000
100
10
1.0
.001
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS

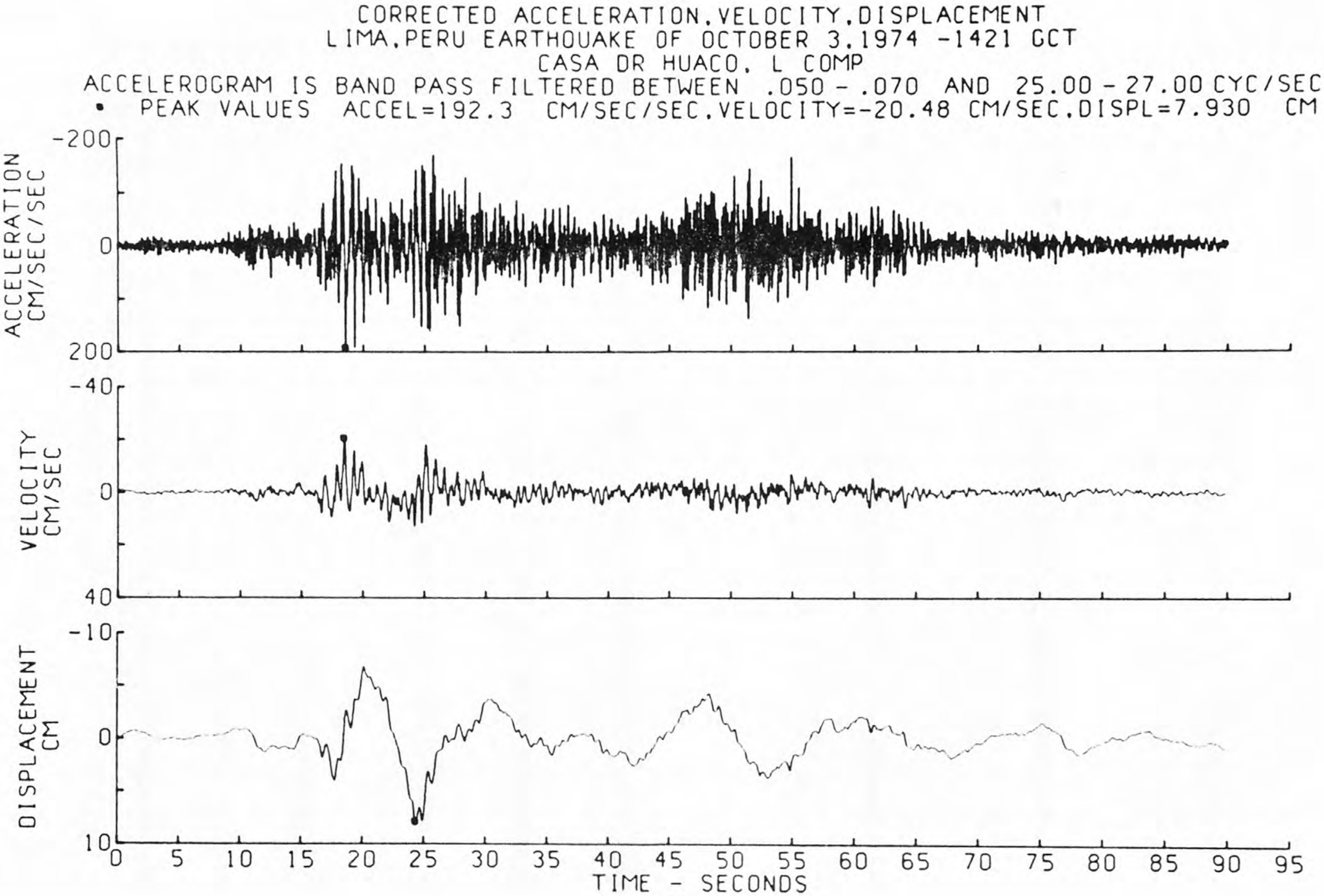

DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST GEOF, 10/3/74, 1421GCT, UP
UNITS=CM/SEC
5-10.
10+
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
64 CYCLES
UNDAMPED NATURAL PERIOD-SECONDS
0
1
2
3
4
0
14
28
RESPONSE DURATION-SEC


DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST GEOF, 10/3/74, 1421GCT, N82W
UNITS=CM/SEC
10-20.
20-30.
30+
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
64 CYCLES
0
1
2
3
4
0
20
40

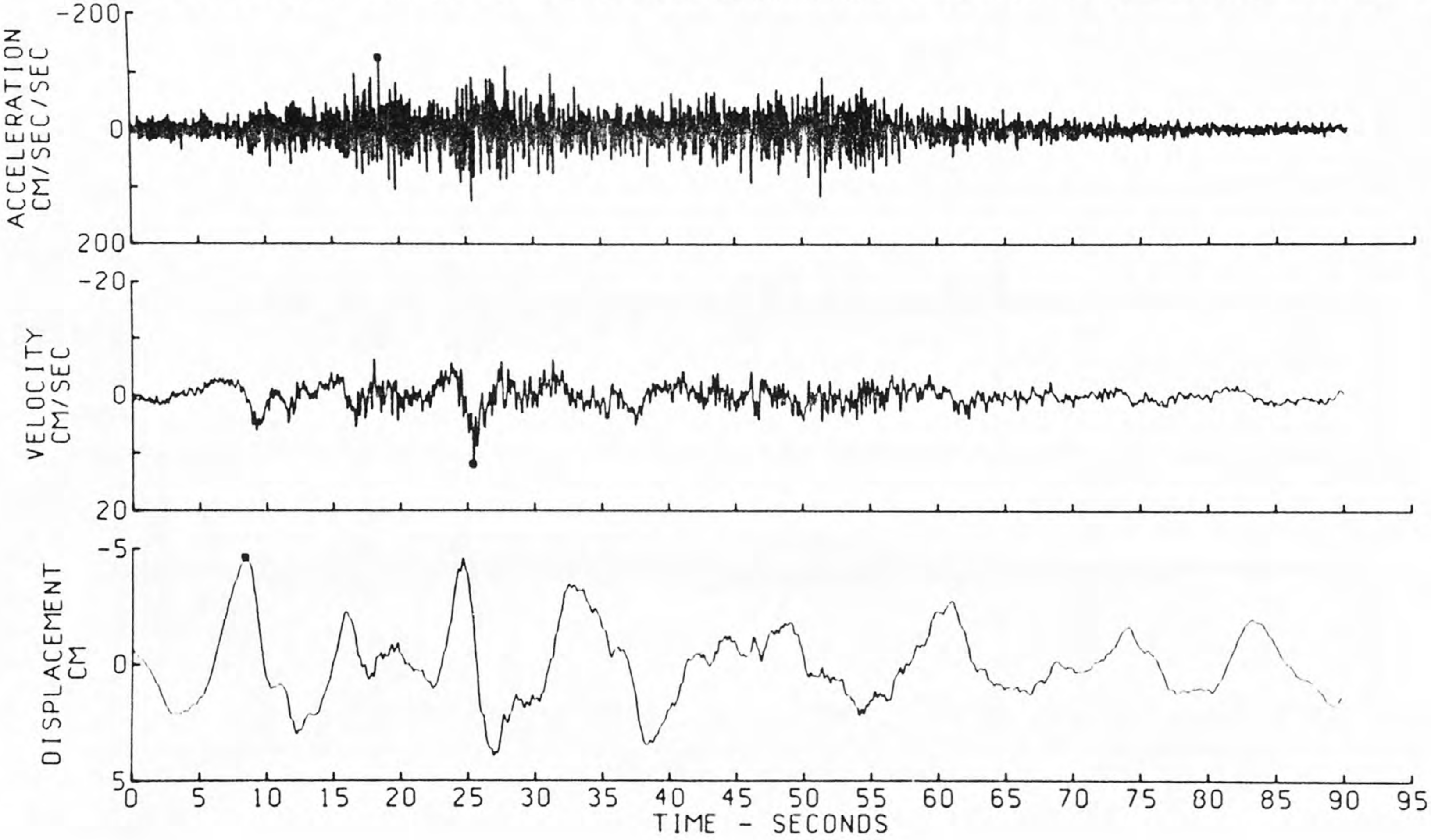

DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST GEOF, 10/3/74, 1421GCT, N08E
UNITS=CM/SEC
5-10.
10-15.
15-20.
20-25.
25+
UNDAMPED NATURAL PERIOD-SECONDS
0
1
2
3
4
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
64 CYCLES
0
22
44
RESPONSE DURATION-SEC


LIMA, PERU, CASA DR. HUACO, 10/3/74, 1421GCT
L
V
T
ACCELERATION IN G/10
TIME IN SECONDS

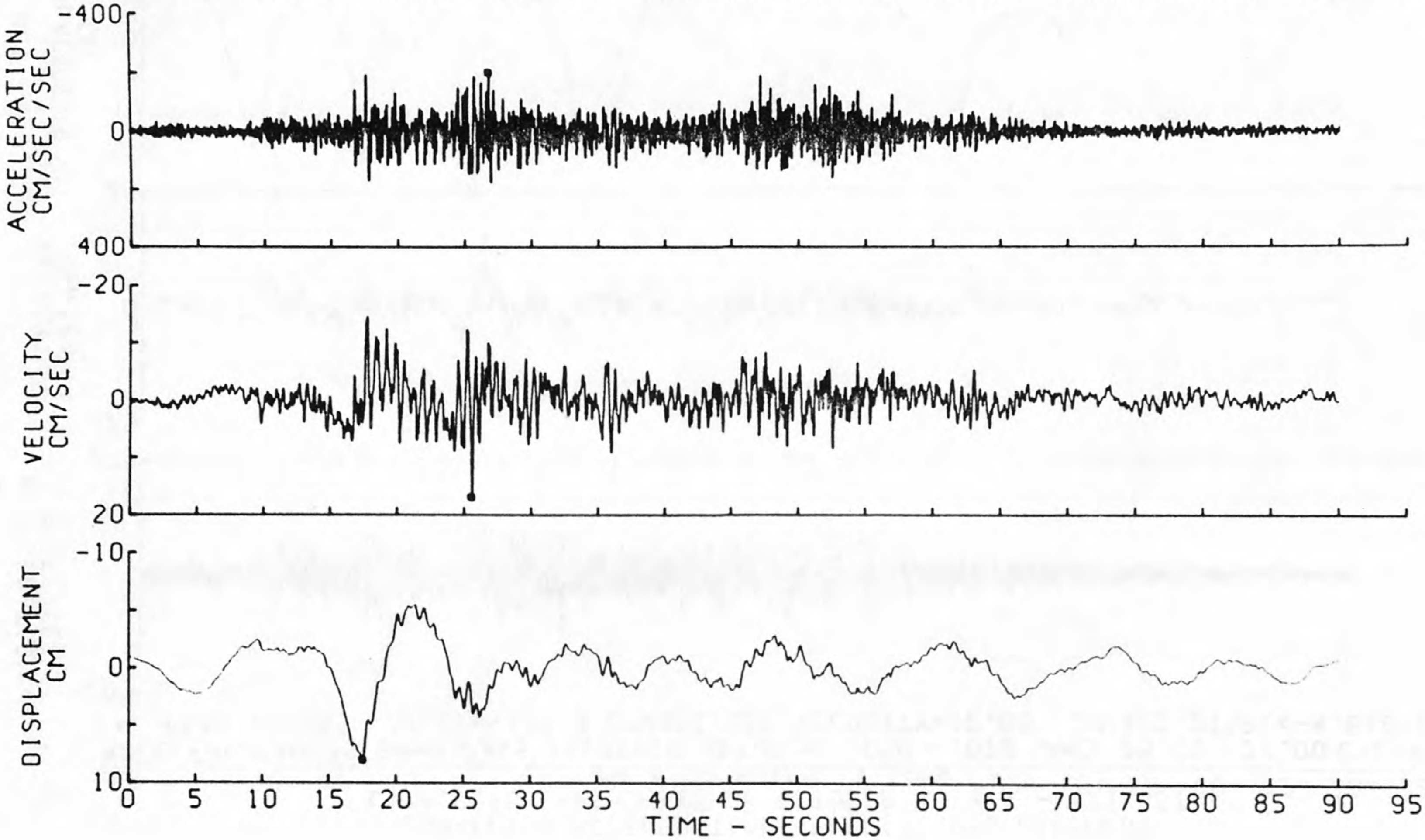

LIMA, PERU, CASA DR. HUACO, 10/3/74, 1421GCT
L
V
T
ACCELERATION IN G/10
TIME IN SECONDS

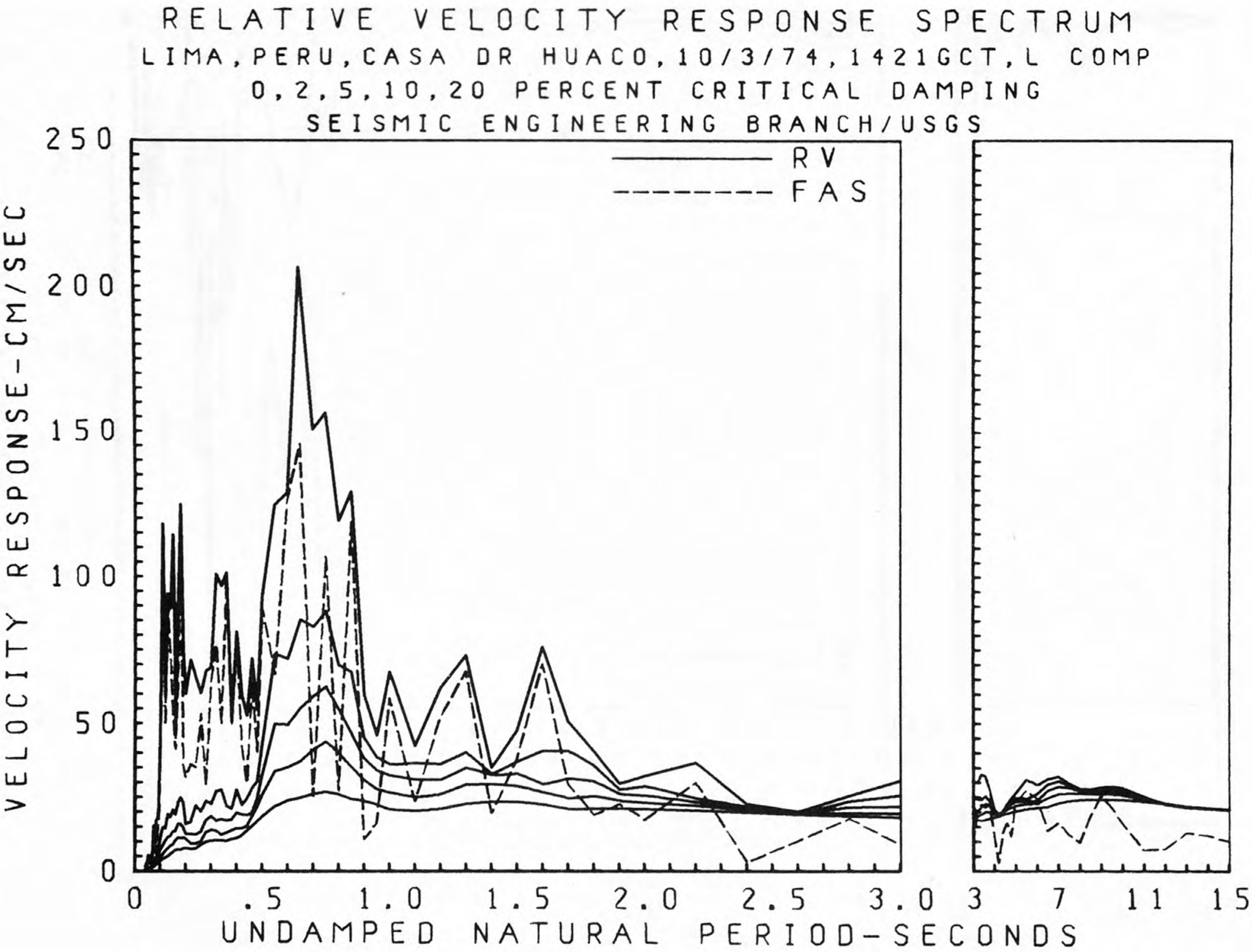

CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF OCTOBER 3, 1974 -1421 GCT
CASA DR HUACO, L COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .050 - .070 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=192.3 CM/SEC/SEC, VELOCITY=-20.48 CM/SEC, DISPL=7.930 CM
ACCELERATION CM/SEC/SEC
-200
0
200
VELOCITY CM/SEC
-40
0
40
DISPLACEMENT CM
-10
0
10
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
TIME - SECONDS

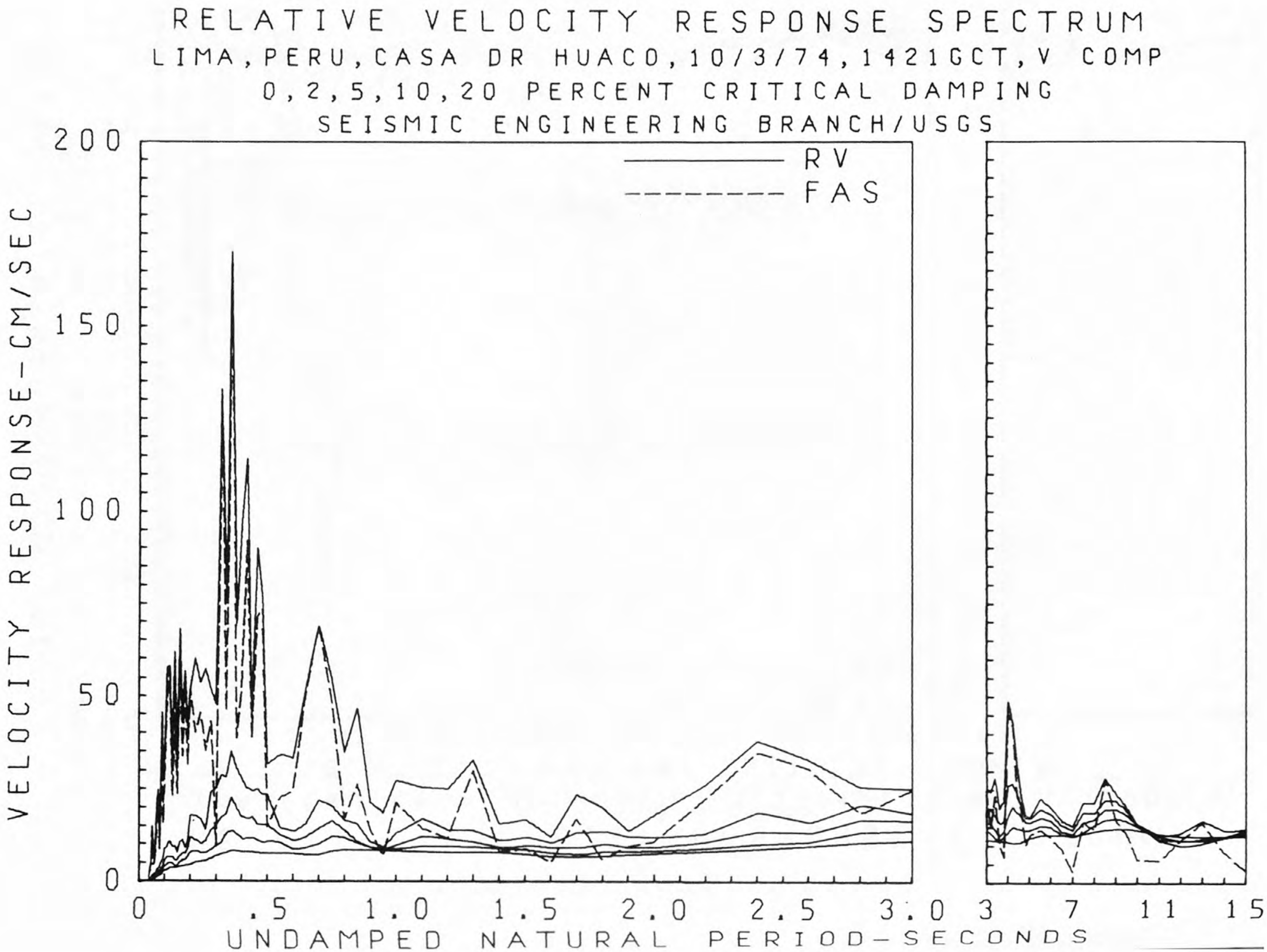
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF OCTOBER 3, 1974 -1421 GCT
CASA DR HUACO, V COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .050 - .070 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-126.3 CM/SEC/SEC, VELOCITY=12.00 CM/SEC, DISPL=-4.610 CM



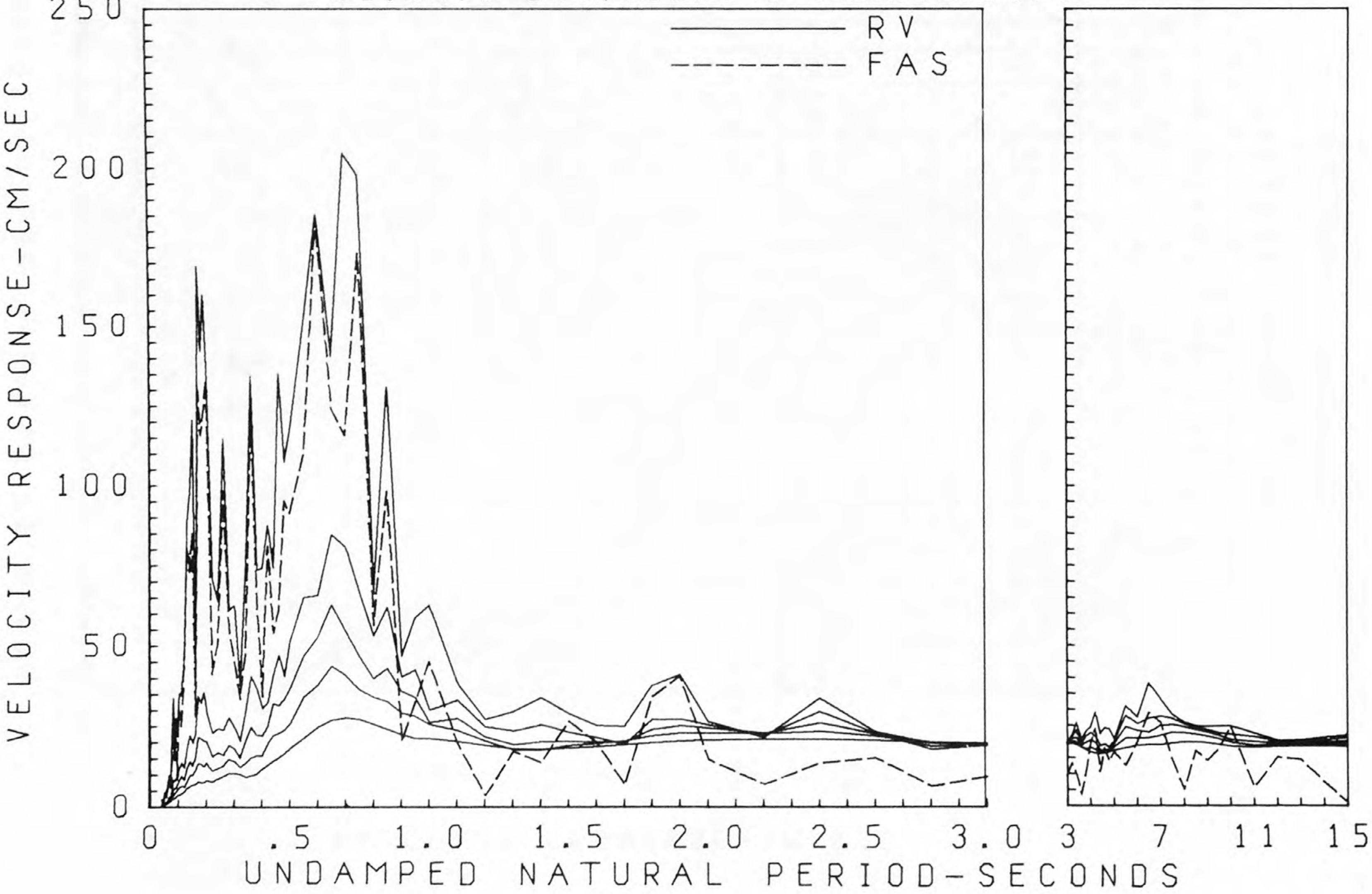
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF OCTOBER 3, 1974 - 1421 GCT
CASA DR. HUACO, T COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .050 - .070 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-207.1 CM/SEC/SEC, VELOCITY=16.94 CM/SEC, DISPL=8.030 CM

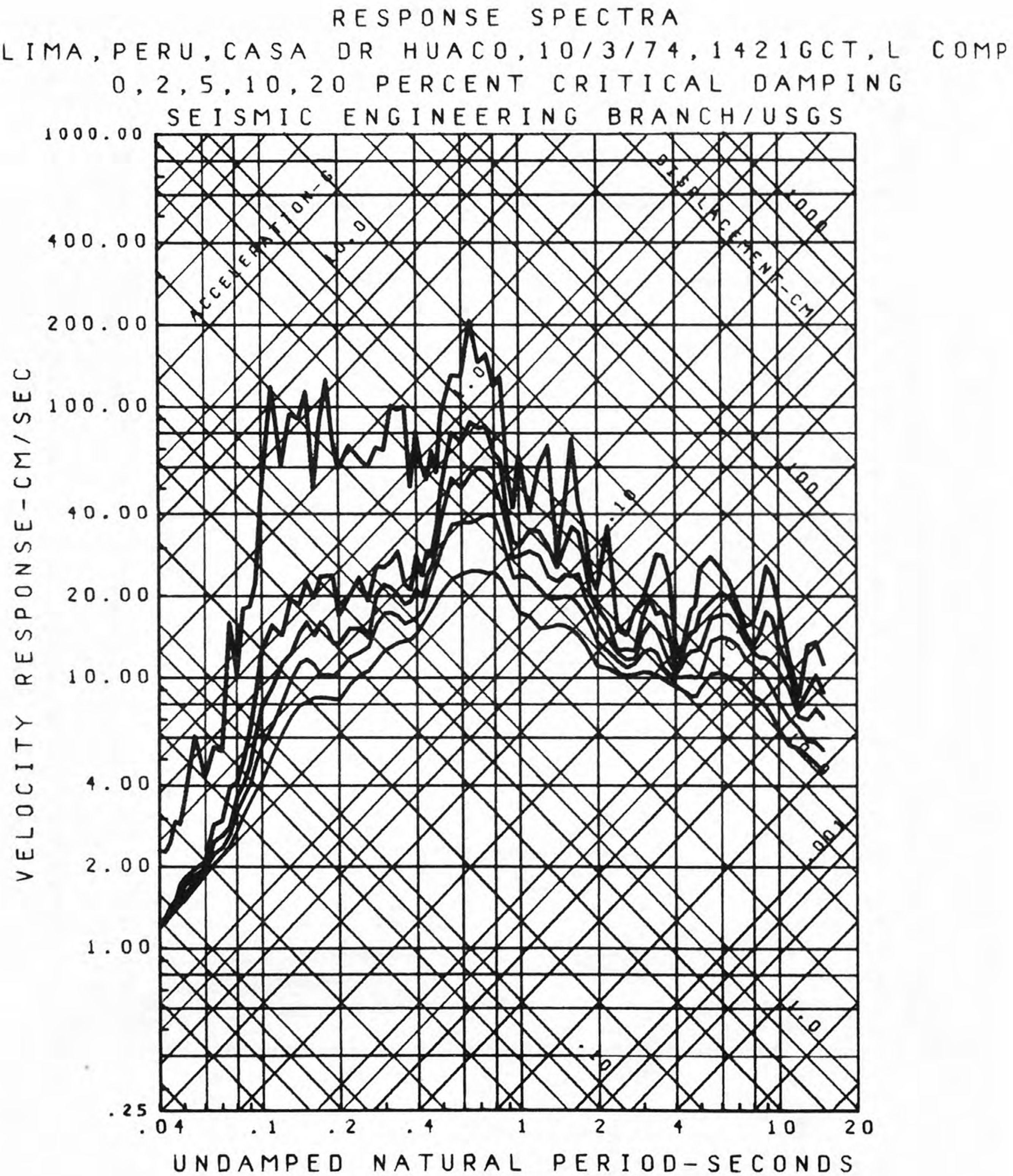


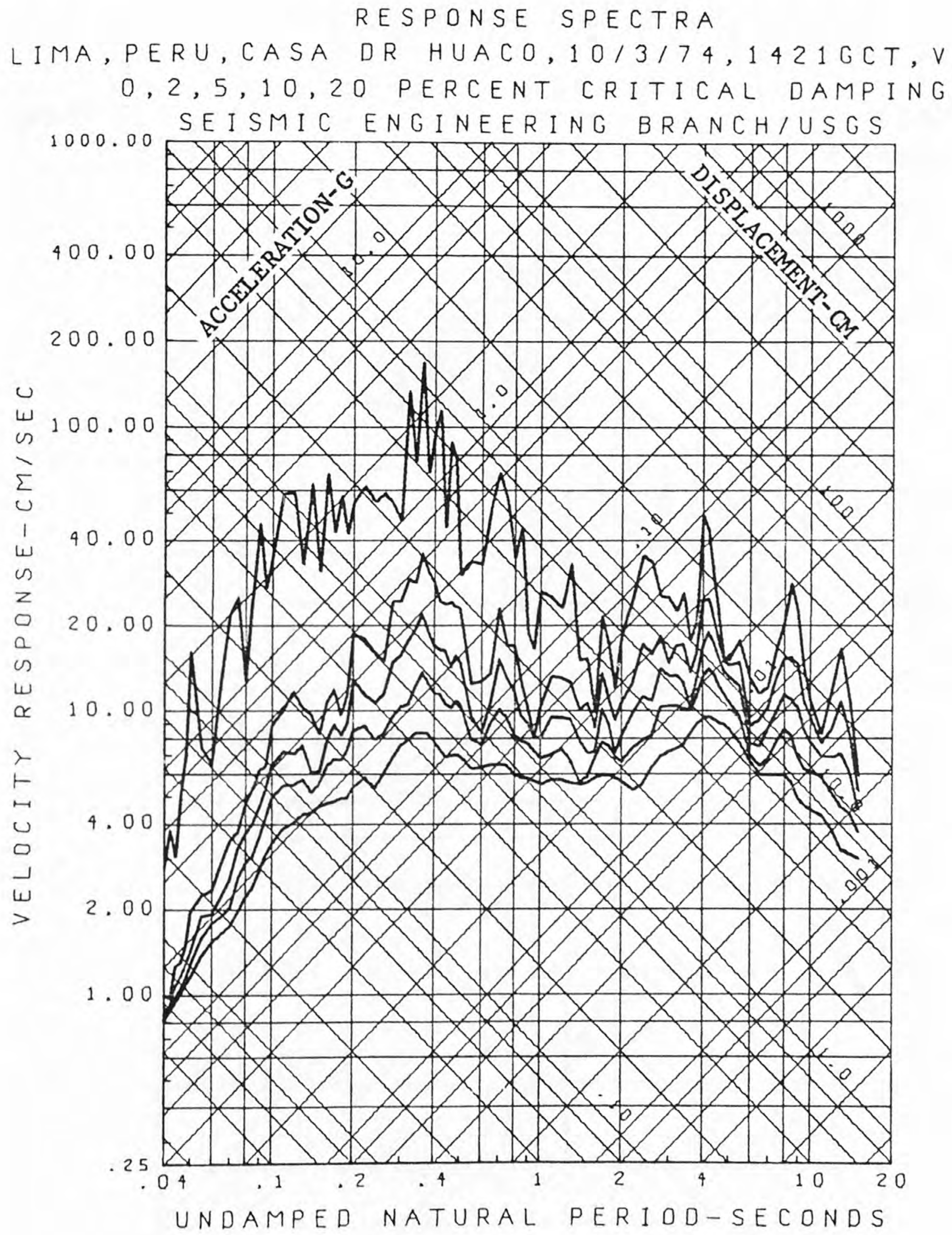

RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, CASA DR HUACO, 10/3/74, 1421GCT, L COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
0
50
100
150
200
250
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS


RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, CASA DR HUACO, 10/3/74, 1421GCT, V COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
200
150
100
50
0
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

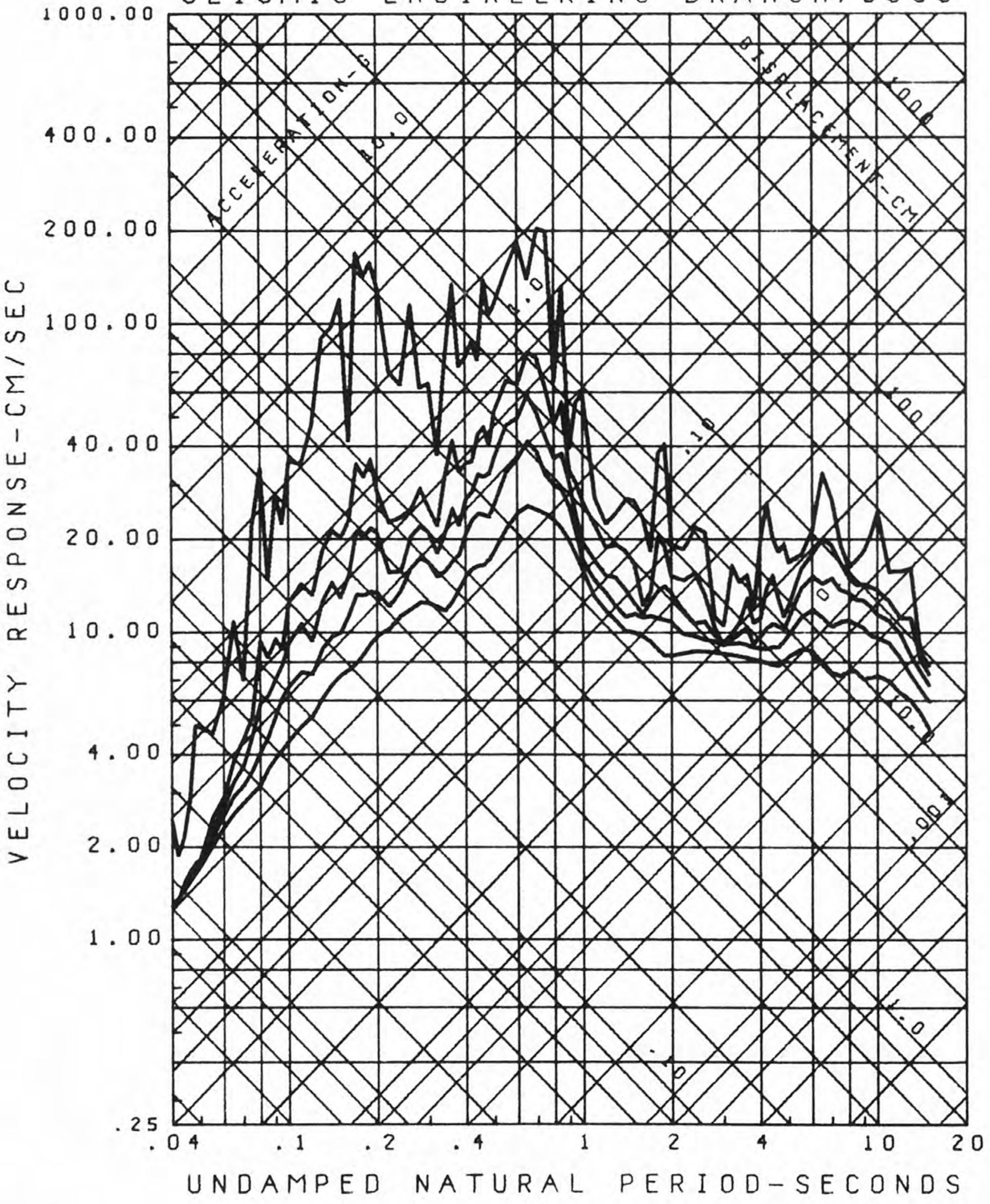
RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, CASA DR HUACO, 10/3/74, 1421GCT, T COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

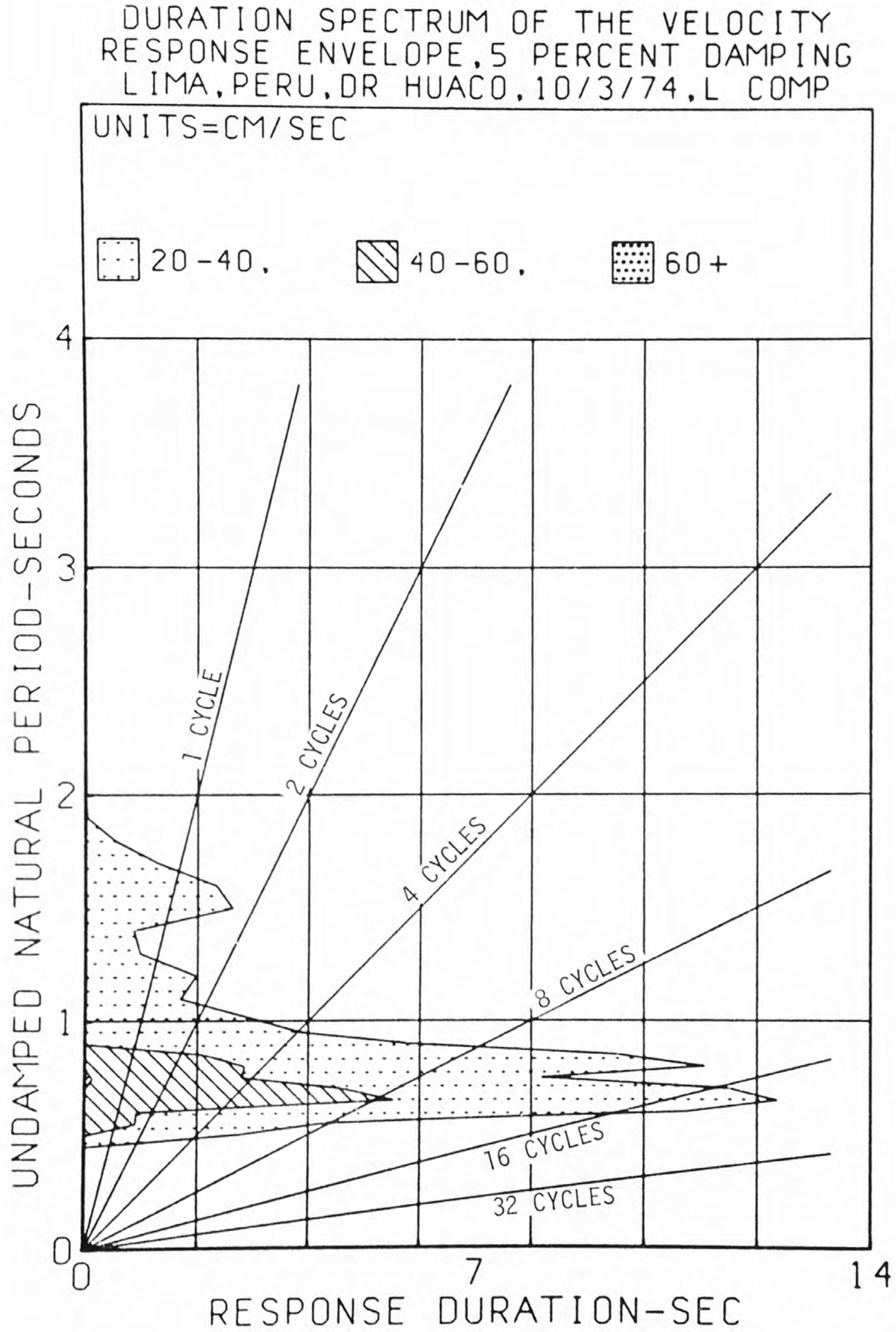


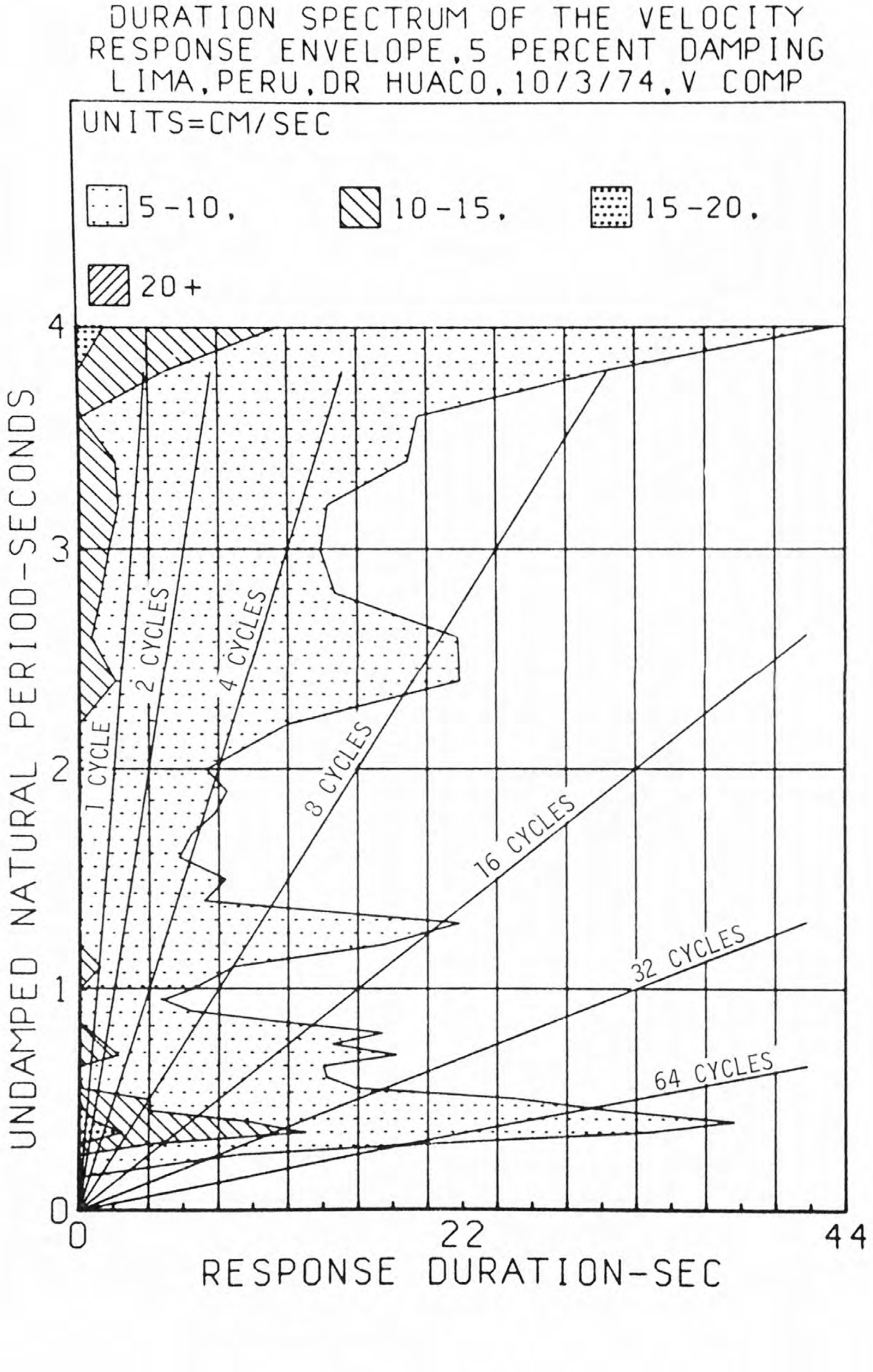

RESPONSE SPECTRA
LIMA,PERU,CASA DR HUACO,10/3/74,1421GCT,L COMP
0,2,5,10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
.04
.1
.2
.4
1
2
4
10
20

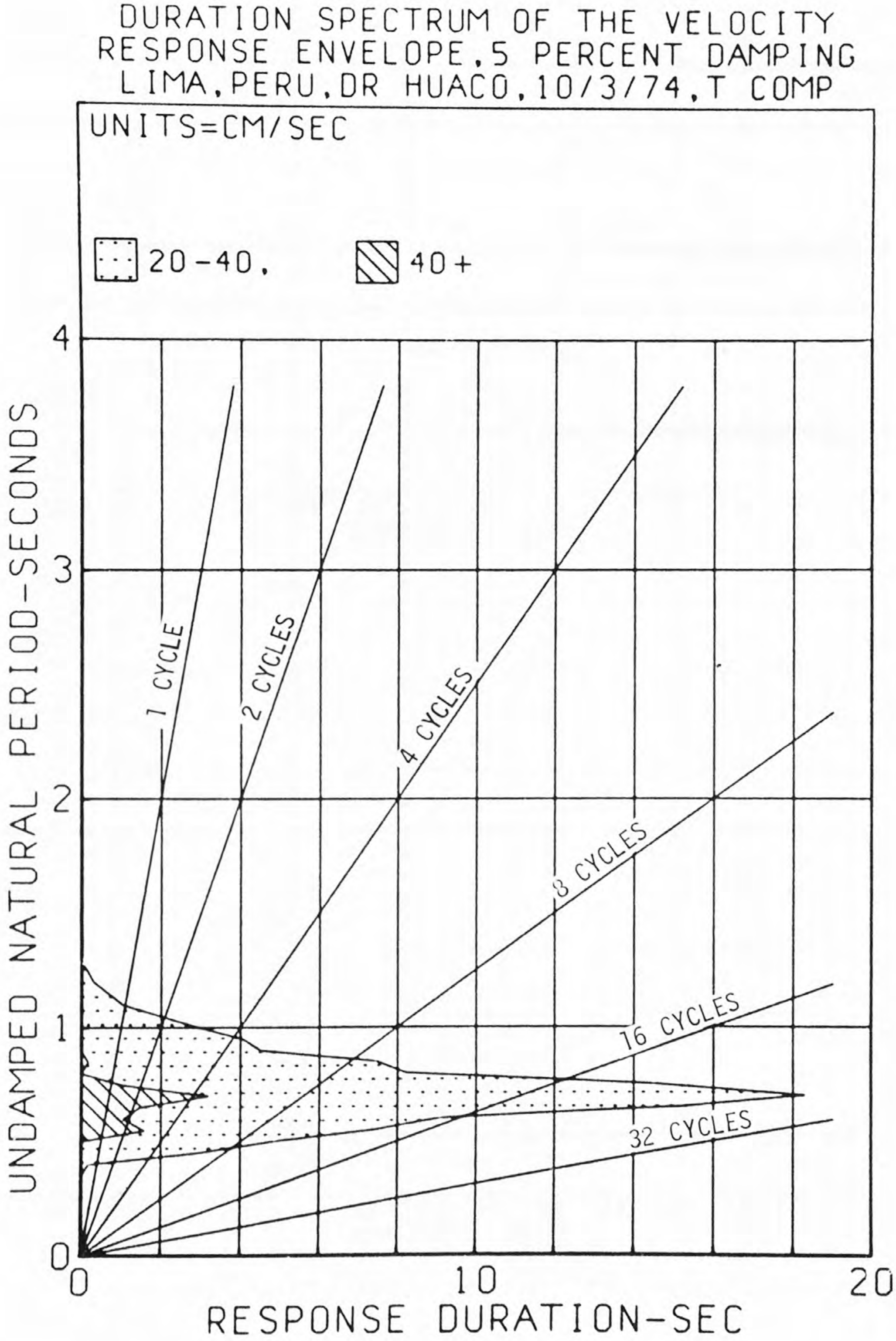

RESPONSE SPECTRA
LIMA, PERU, CASA DR HUACO, 10/3/74, 1421GCT, V
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
ACCELERATION-G
DISPLACEMENT-CM
VELOCITY RESPONSE-CM/SEC
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS

RESPONSE SPECTRA
LIMA, PERU, CASA DR HUACO, 10/3/74, 1421GCT, T COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

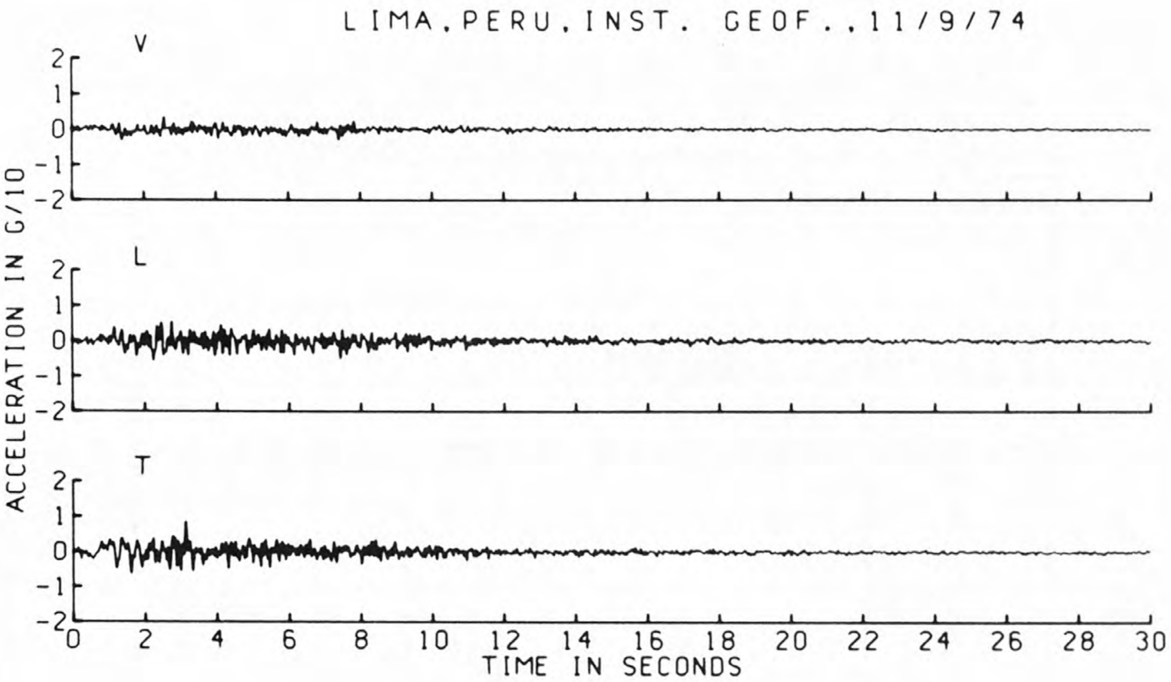


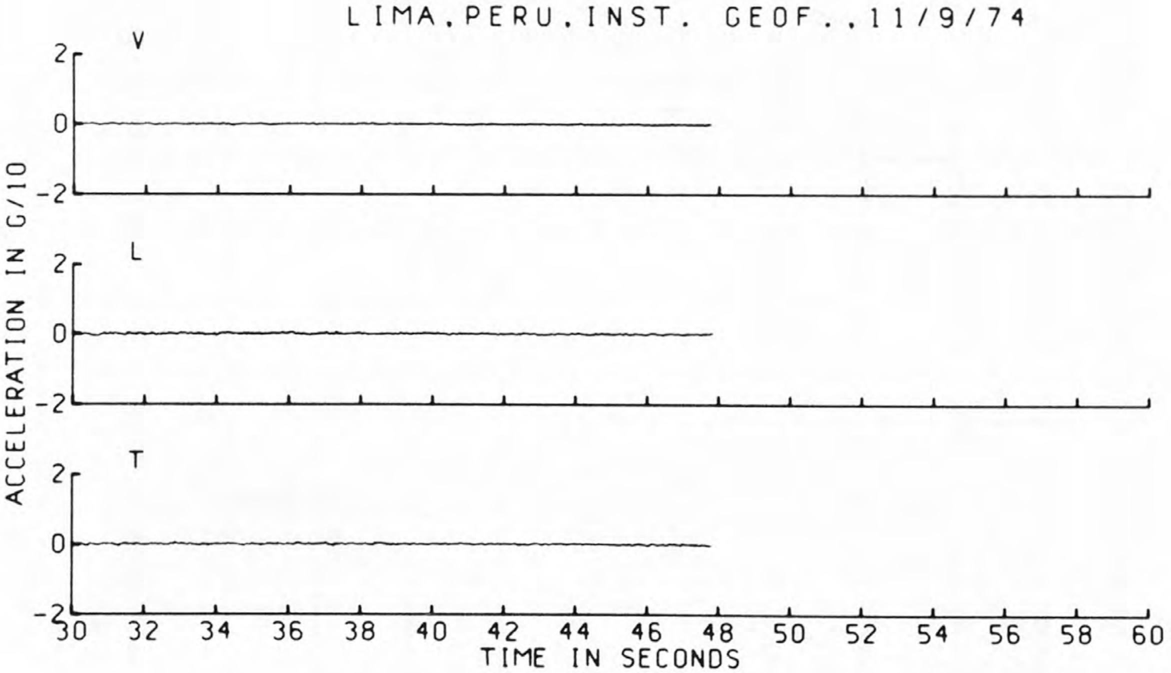

DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, DR HUACO, 10/3/74, L COMP
UNITS=CM/SEC
20-40.
40-60.
60+
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
0
1
2
3
4
0
7
14


DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, DR HUACO, 10/3/74, V COMP
UNITS=CM/SEC
5-10.
10-15.
15-20.
20+
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
0
1
2
3
4
0
22
44
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
64 CYCLES

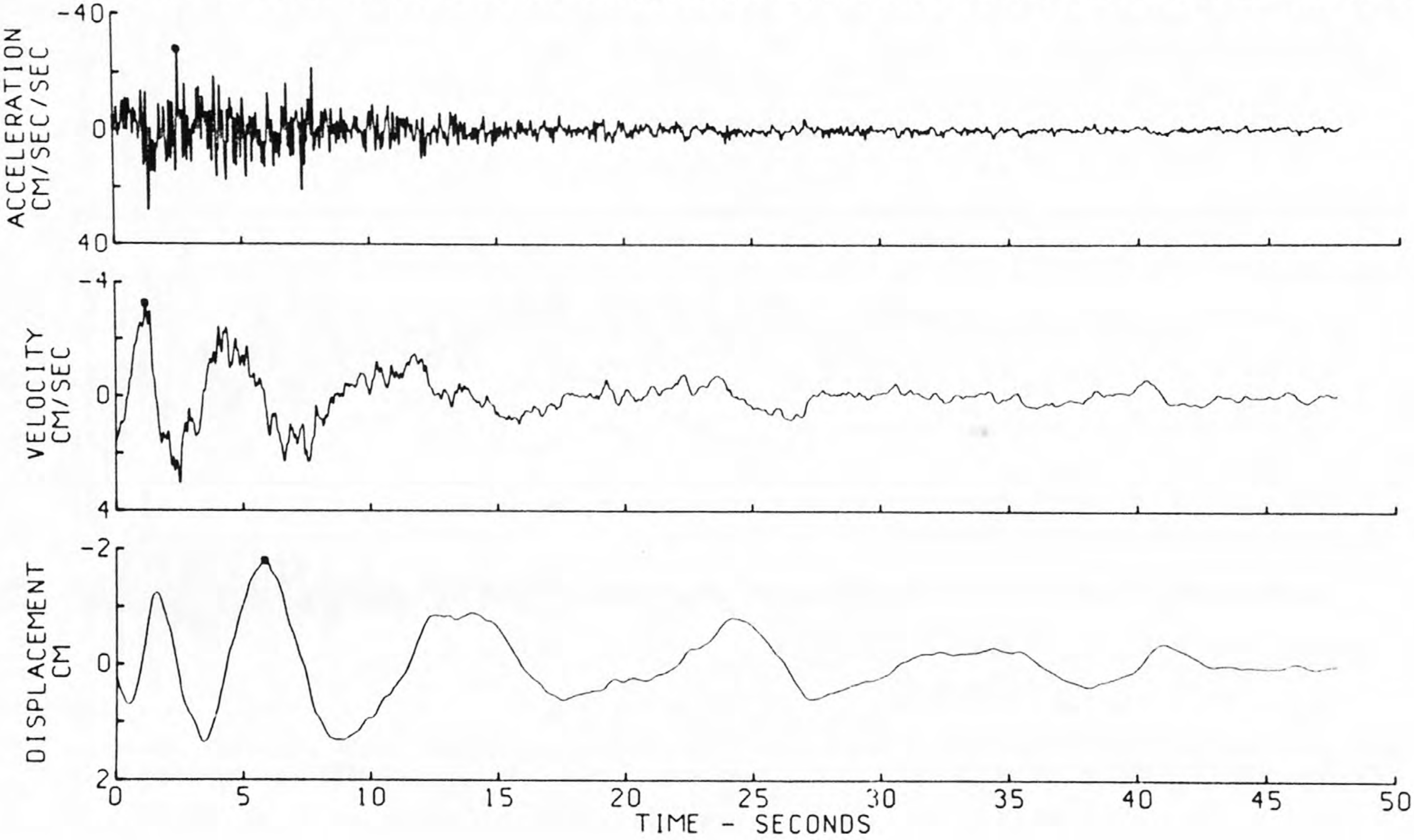


DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, DR HUACO, 10/3/74, T COMP
UNITS=CM/SEC
20-40.
40+
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
0
1
2
3
4
10
20

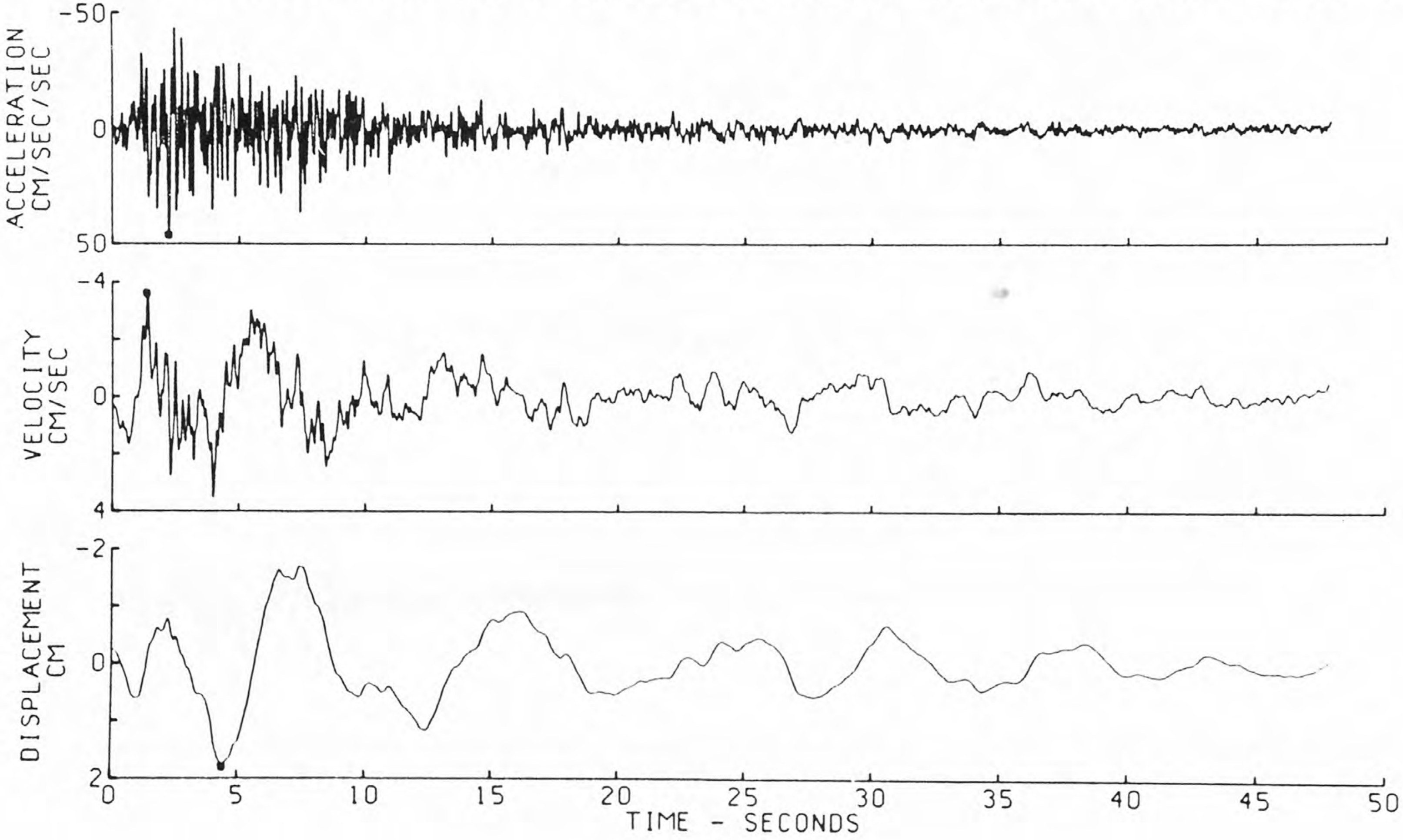

LIMA, PERU, INST. GEOF., 11/9/74
V
L
T
ACCELERATION IN G/10
TIME IN SECONDS


LIMA, PERU, INST. GEOF., 11/9/74
V
L
T
ACCELERATION IN G/10
TIME IN SECONDS

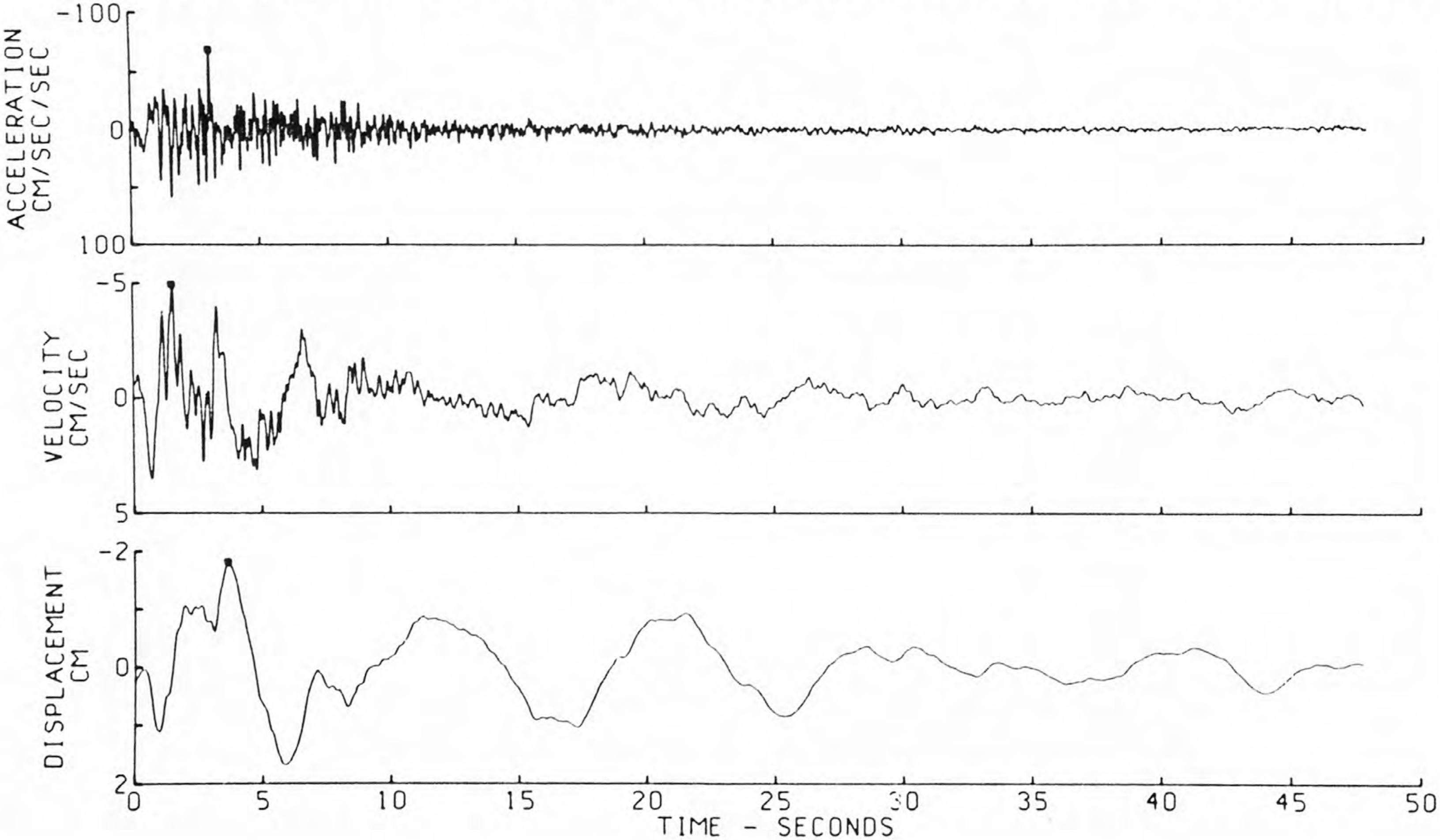
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF NOVEMBER 9, 1974
INSTITUTO GEOFISICO DEL PERU, V COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .070 - .100 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-28.00 CM/SEC/SEC, VELOCITY=-3.240 CM/SEC, DISPL=-1.790 CM



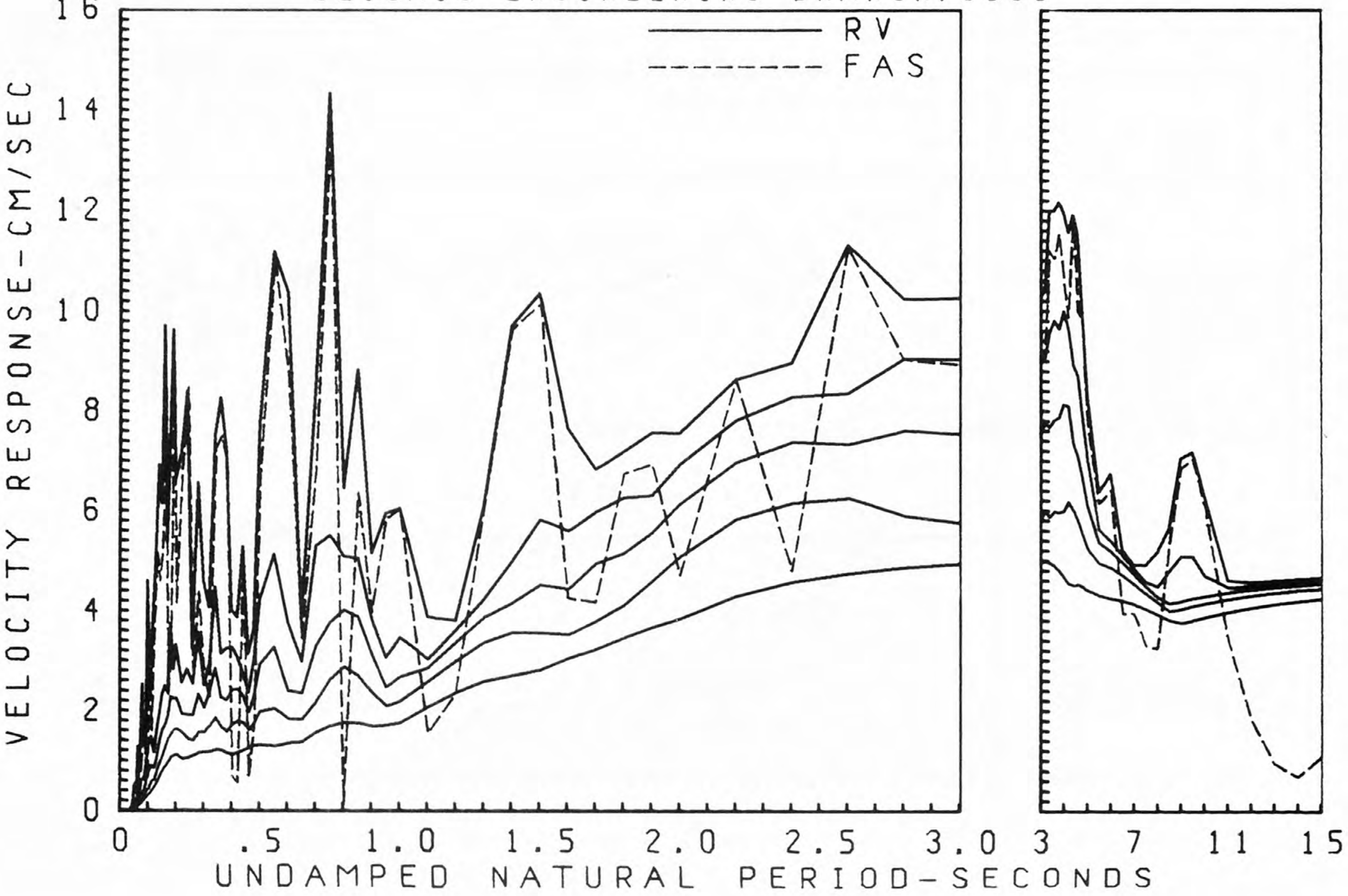
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF NOVEMBER 9, 1974
INSTITUTO GEOFISICO DEL PERU, L COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .070 - .100 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=46.21 CM/SEC/SEC, VELOCITY=-3.600 CM/SEC, DISPL=1.800 CM



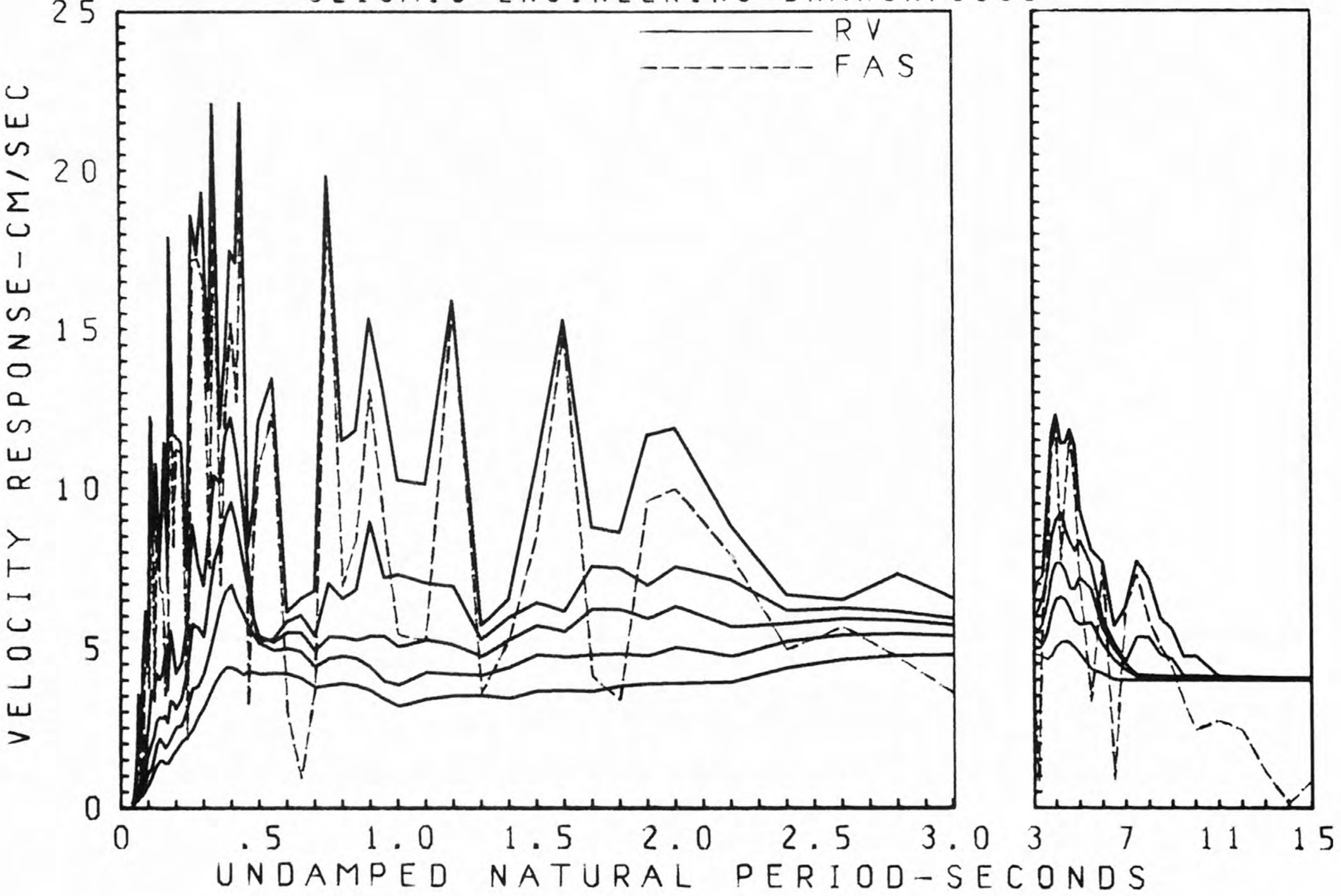
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF NOVEMBER 9, 1974
INSTITUTO GEOFISICO DEL PERU, T COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .070 - .100 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-69.21 CM/SEC/SEC, VELOCITY=-4.910 CM/SEC, DISPL=-1.810 CM

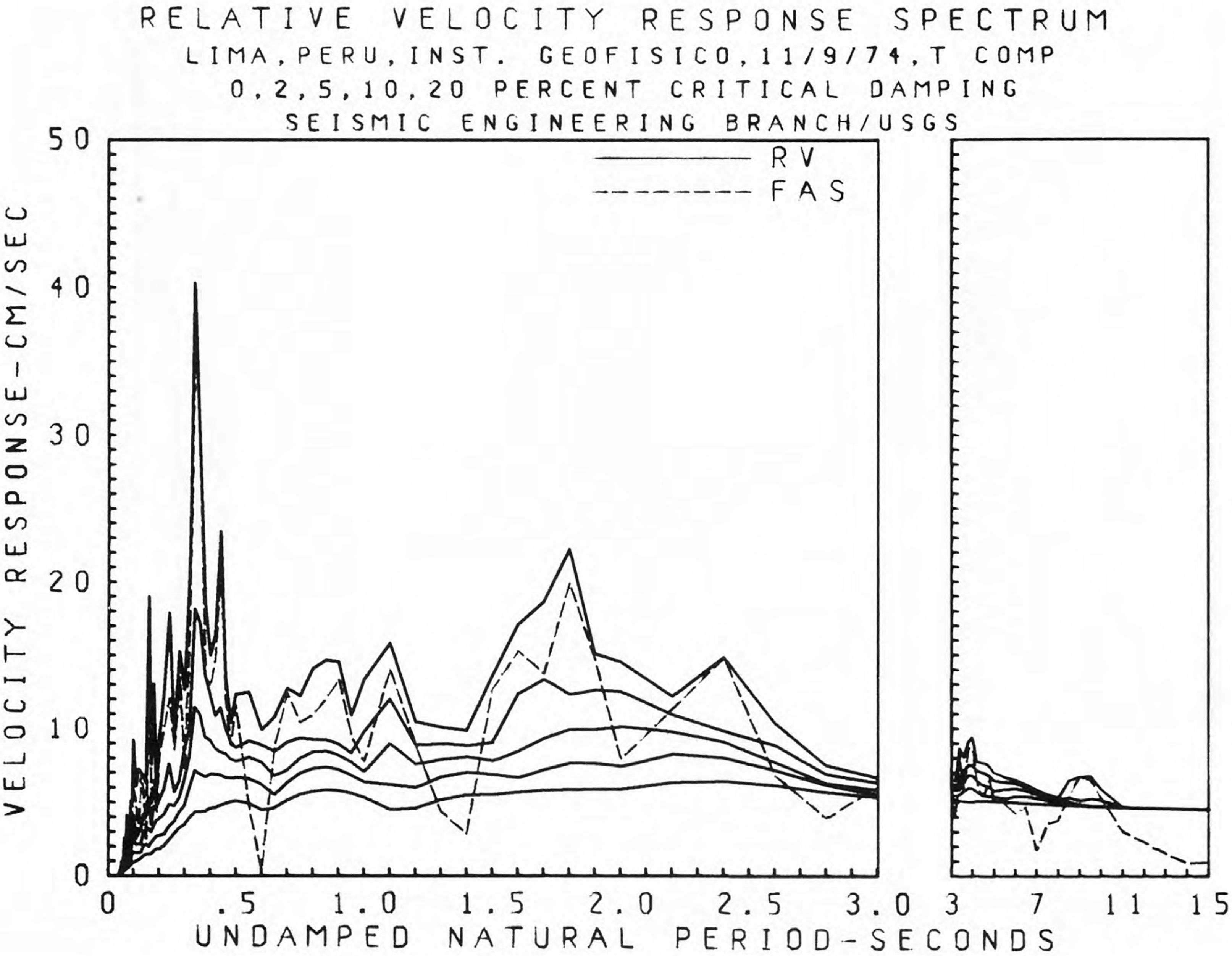


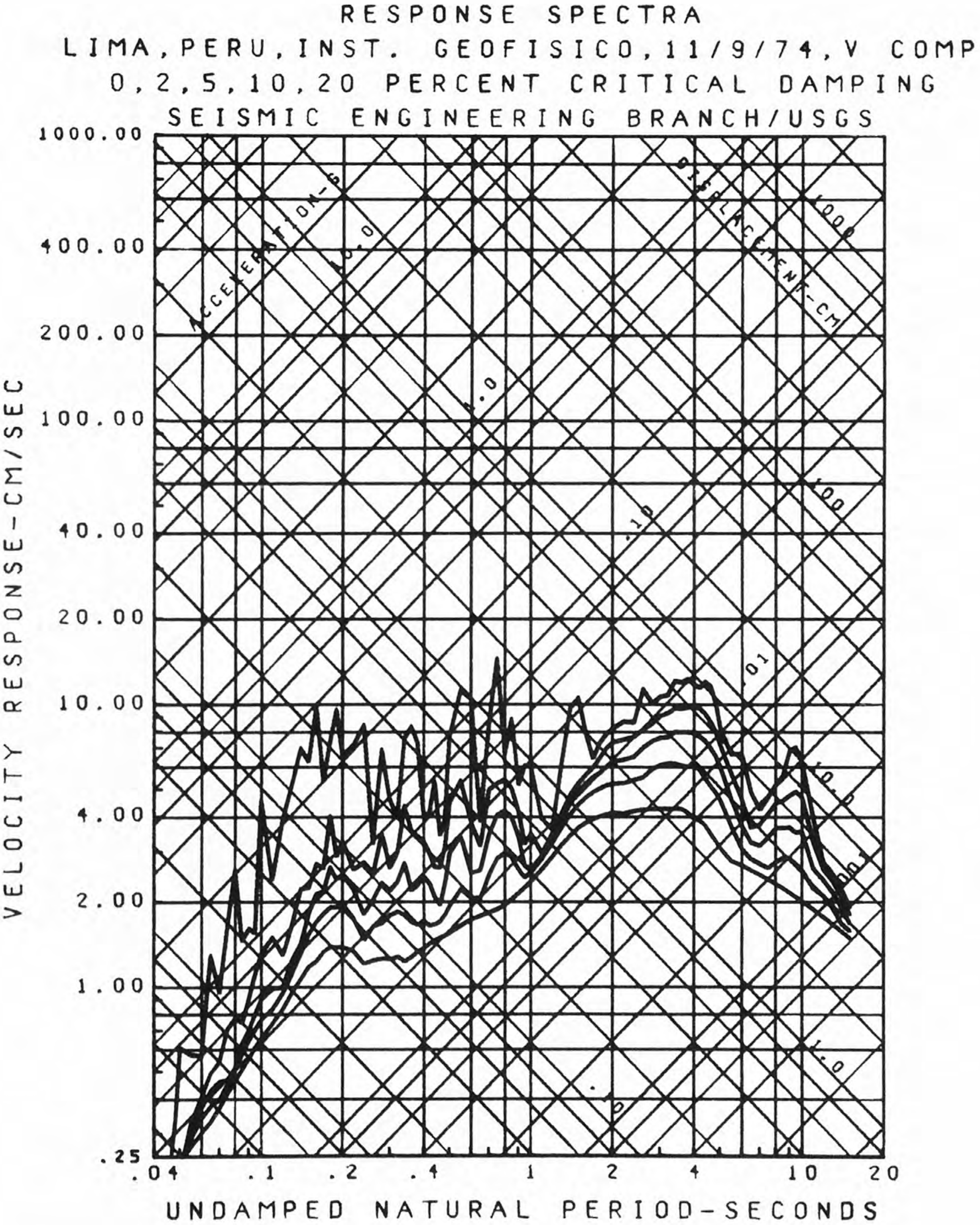
RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST. GEOFISICO, 11/9/74, V COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

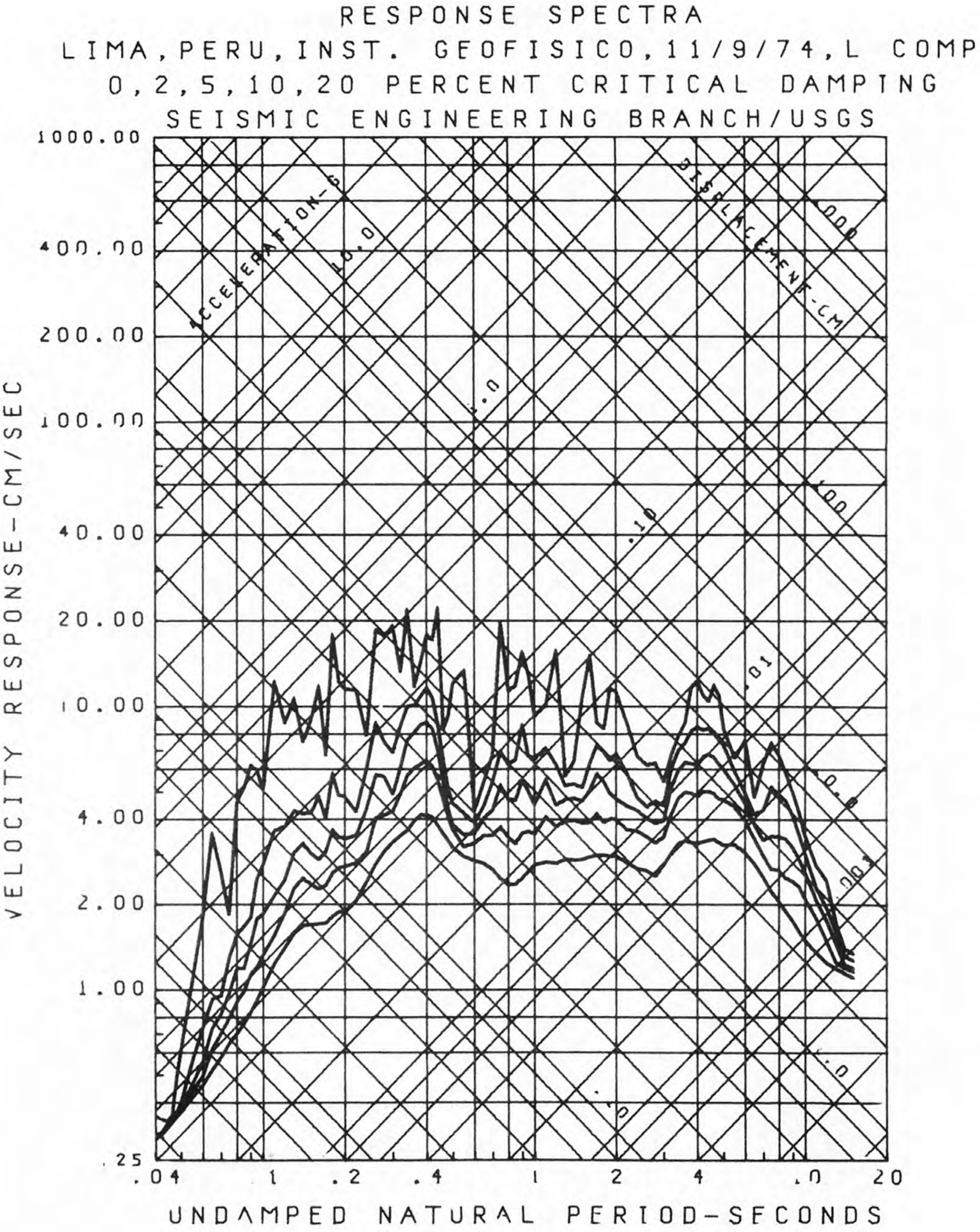


RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST. GEOFISICO, 11/9/74, L COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

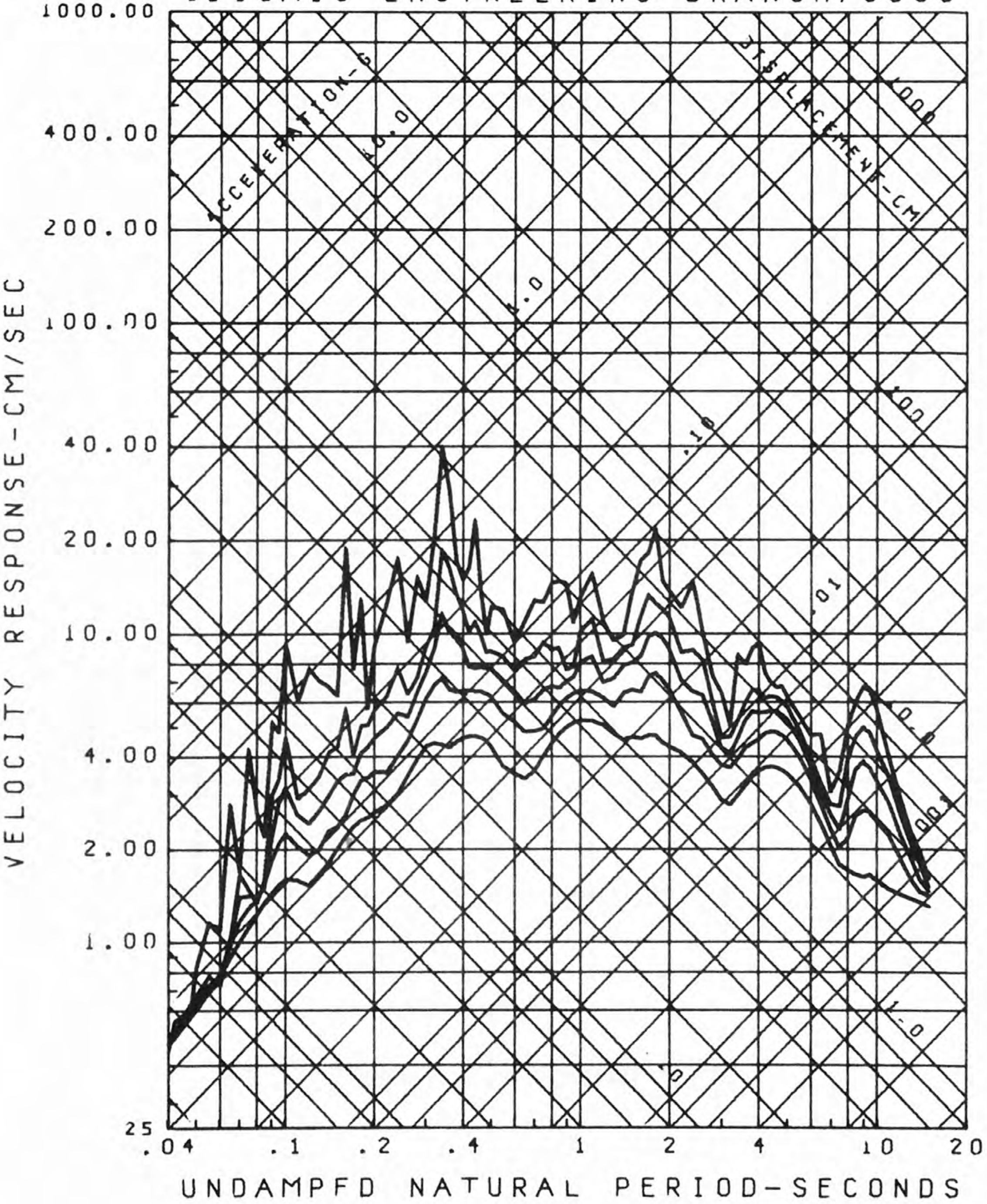


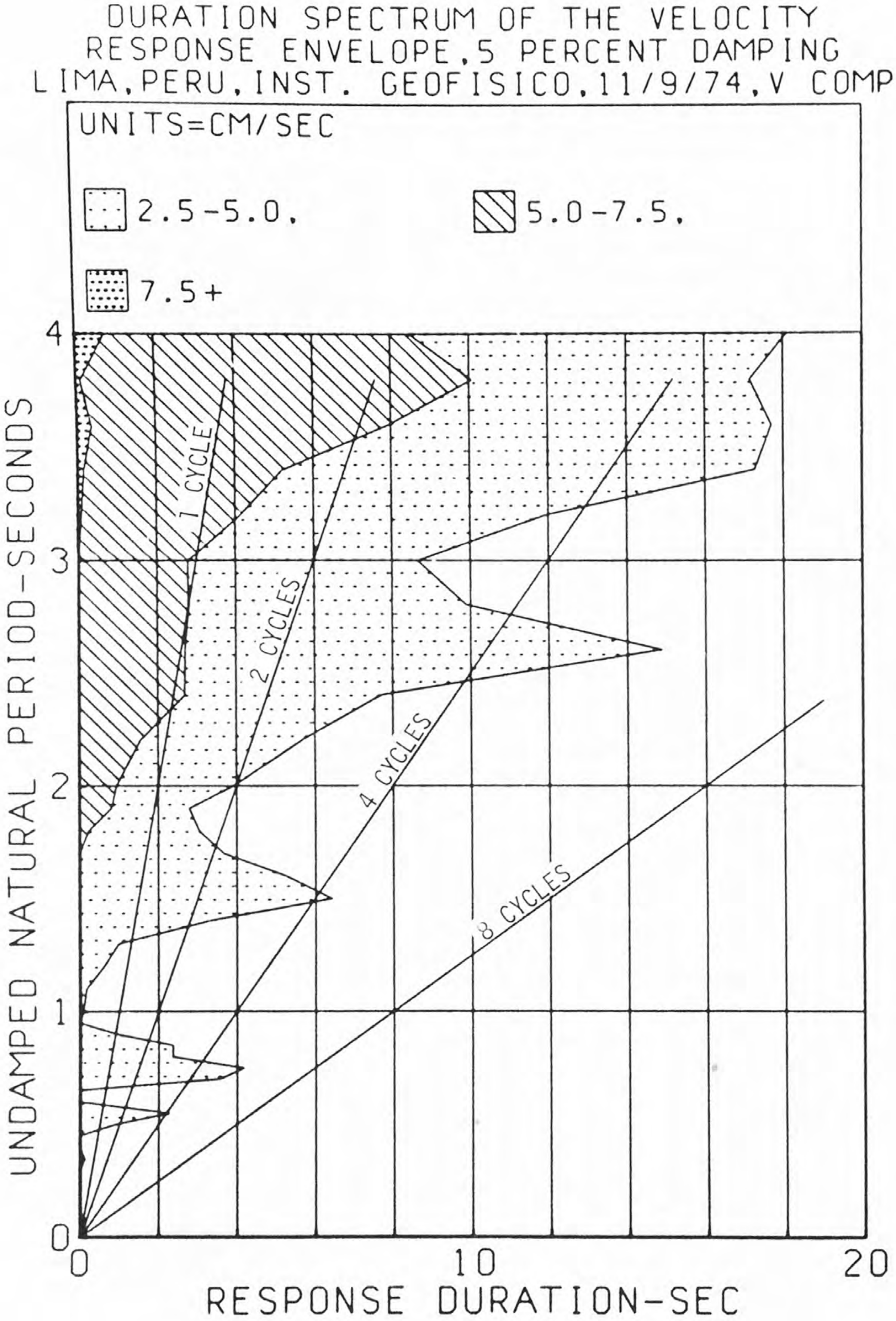

RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, INST. GEOFISICO, 11/9/74, T COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
50
40
30
20
10
0
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

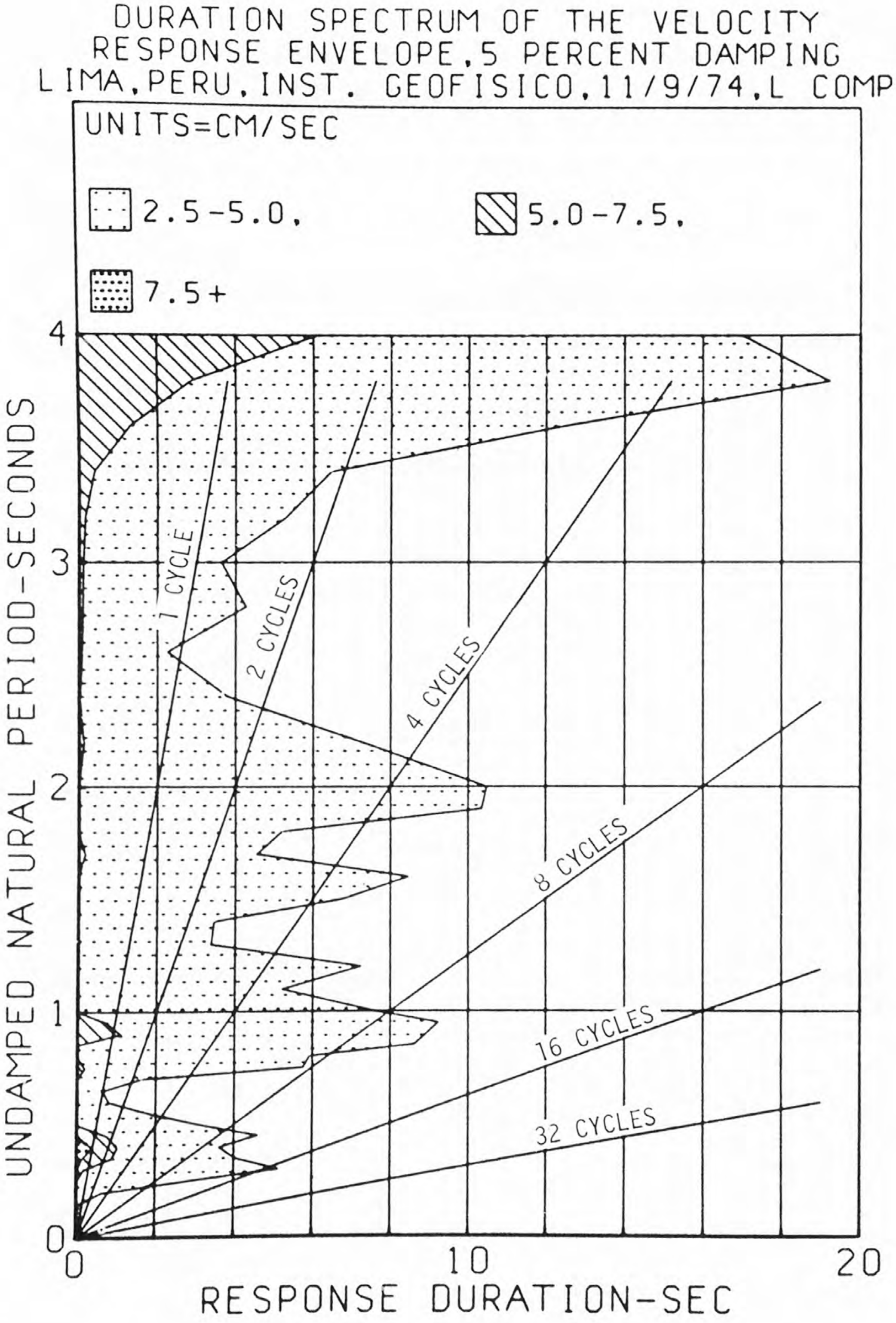

RESPONSE SPECTRA
LIMA,PERU,INST. GEOFISICO,11/9/74,V COMP
0,2,5,10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
VELOCITY RESPONSE-CM/SEC
ACCELERATION-G
DISPLACEMENT-CM
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS

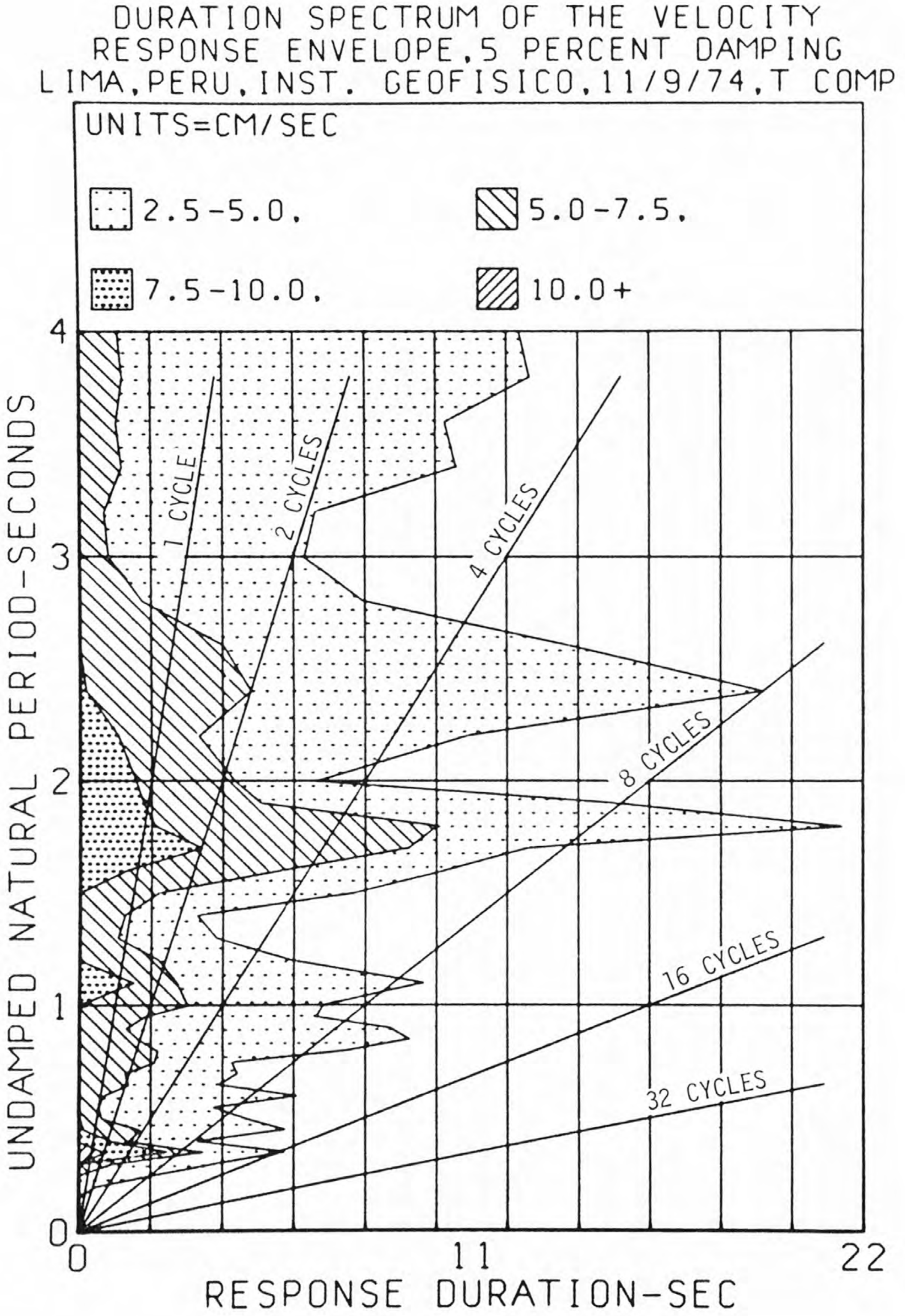

RESPONSE SPECTRA
LIMA,PERU,INST. GEOFISICO,11/9/74,L COMP
0,2,5,10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
VELOCITY RESPONSE-CM/SEC
ACCELERATION-G
DISPLACEMENT-CM
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS

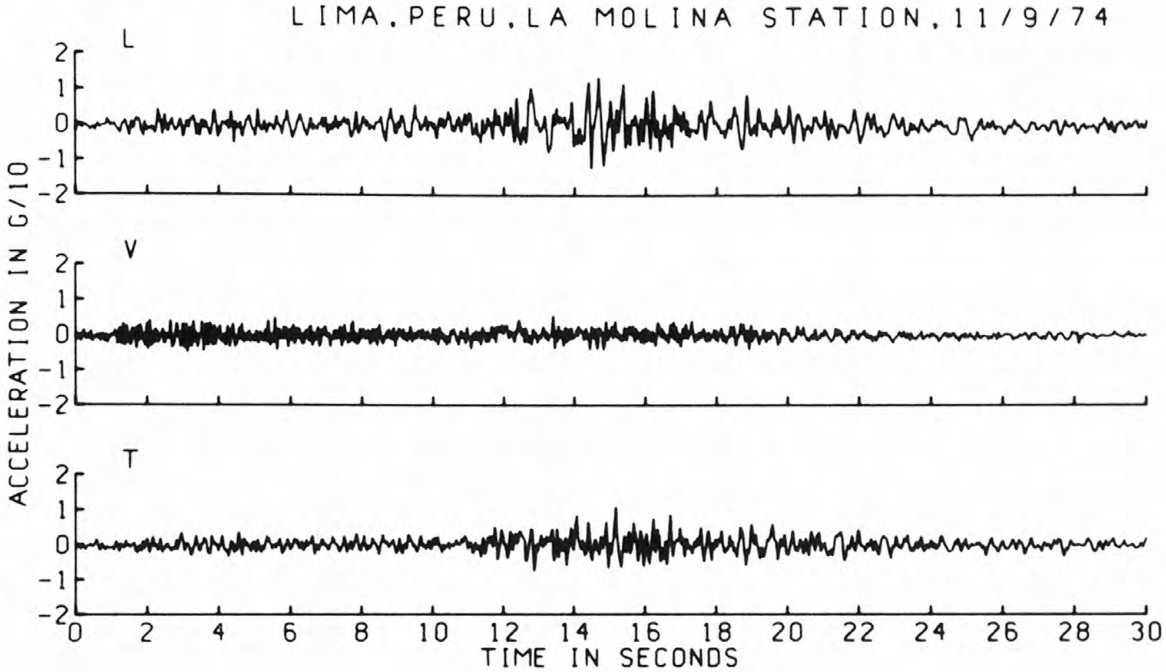
RESPONSE SPECTRA
LIMA.PERU,INST. GEOFISICO,11/9/74,T COMP
0,2,5,10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

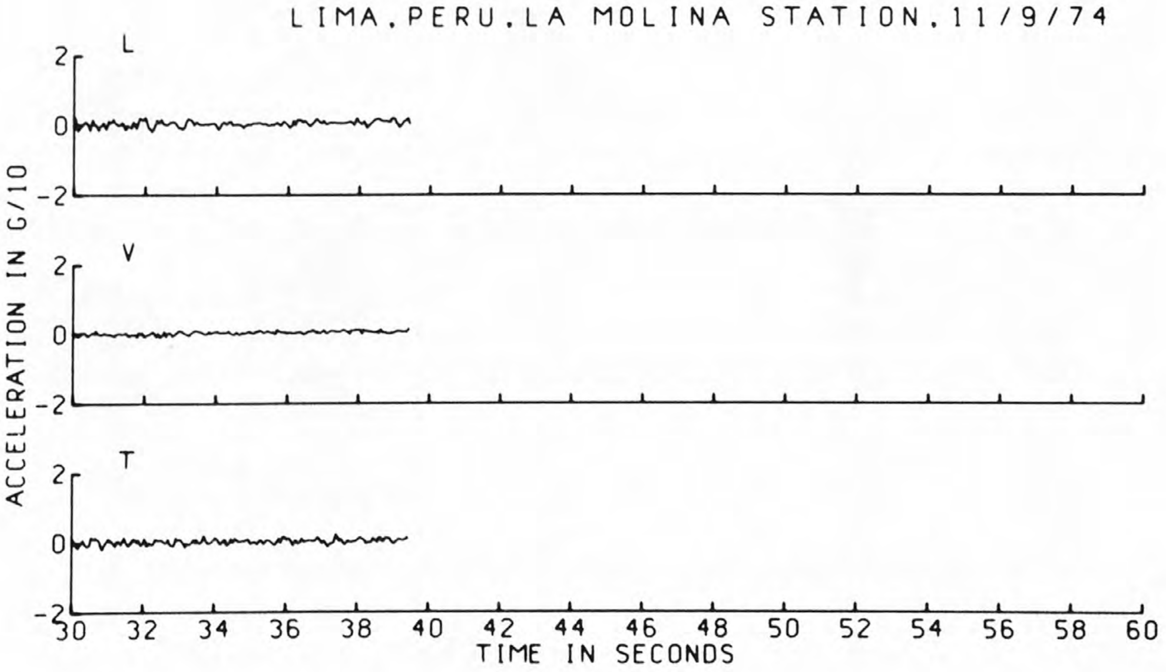



DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST. GEOFISICO, 11/9/74, V COMP
UNITS=CM/SEC
2.5-5.0,
5.0-7.5,
7.5+
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
0
1
2
3
4
0
10
20

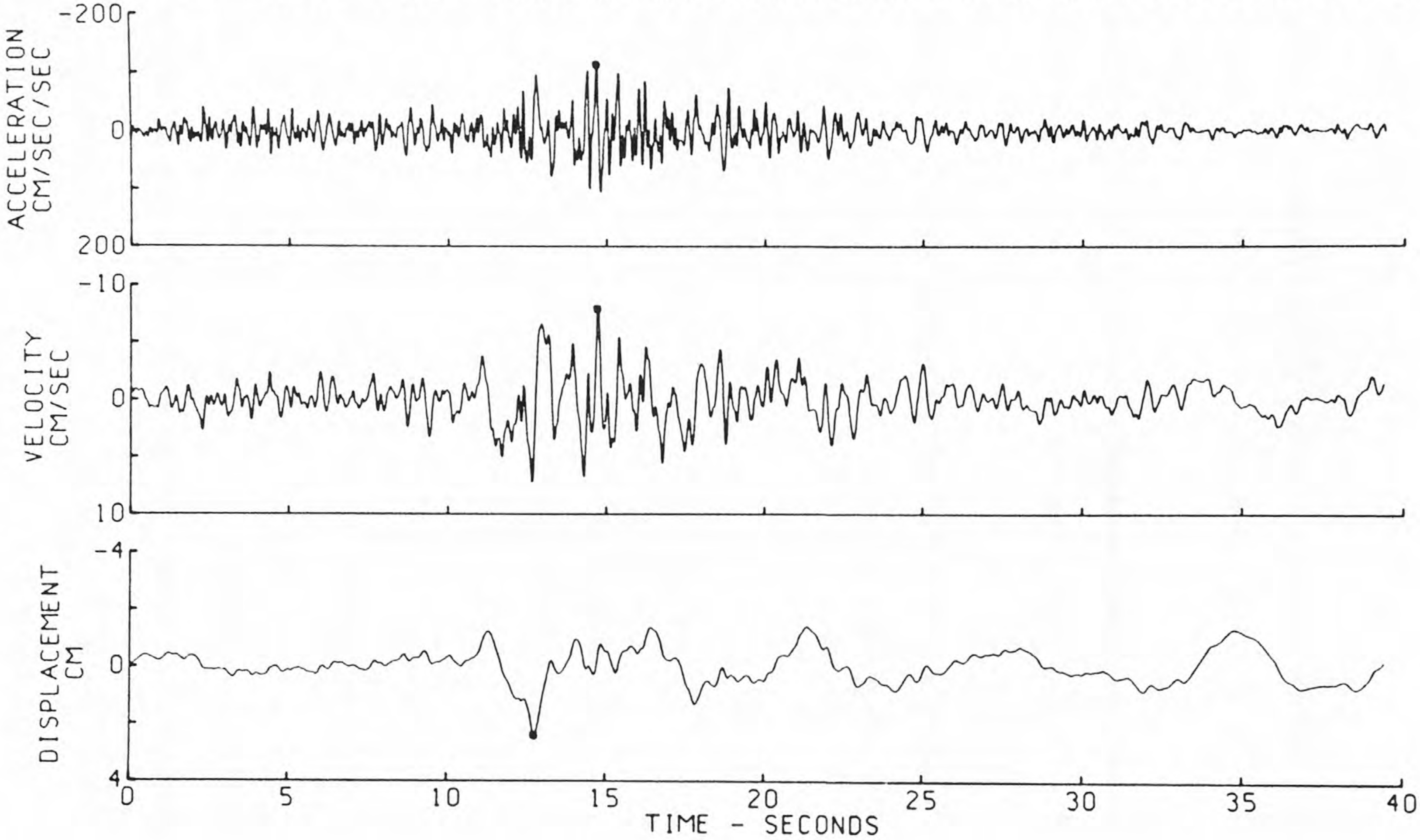

DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST. GEOFISICO, 11/9/74, L COMP
UNITS=CM/SEC
2.5-5.0,
5.0-7.5,
7.5+
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
0
1
2
3
4
0
10
20


DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, INST. GEOFISICO, 11/9/74, T COMP
UNITS=CM/SEC
2.5-5.0,
5.0-7.5,
7.5-10.0,
10.0+
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
UNDAMPED NATURAL PERIOD-SECONDS
0
1
2
3
4
0
11
22
RESPONSE DURATION-SEC

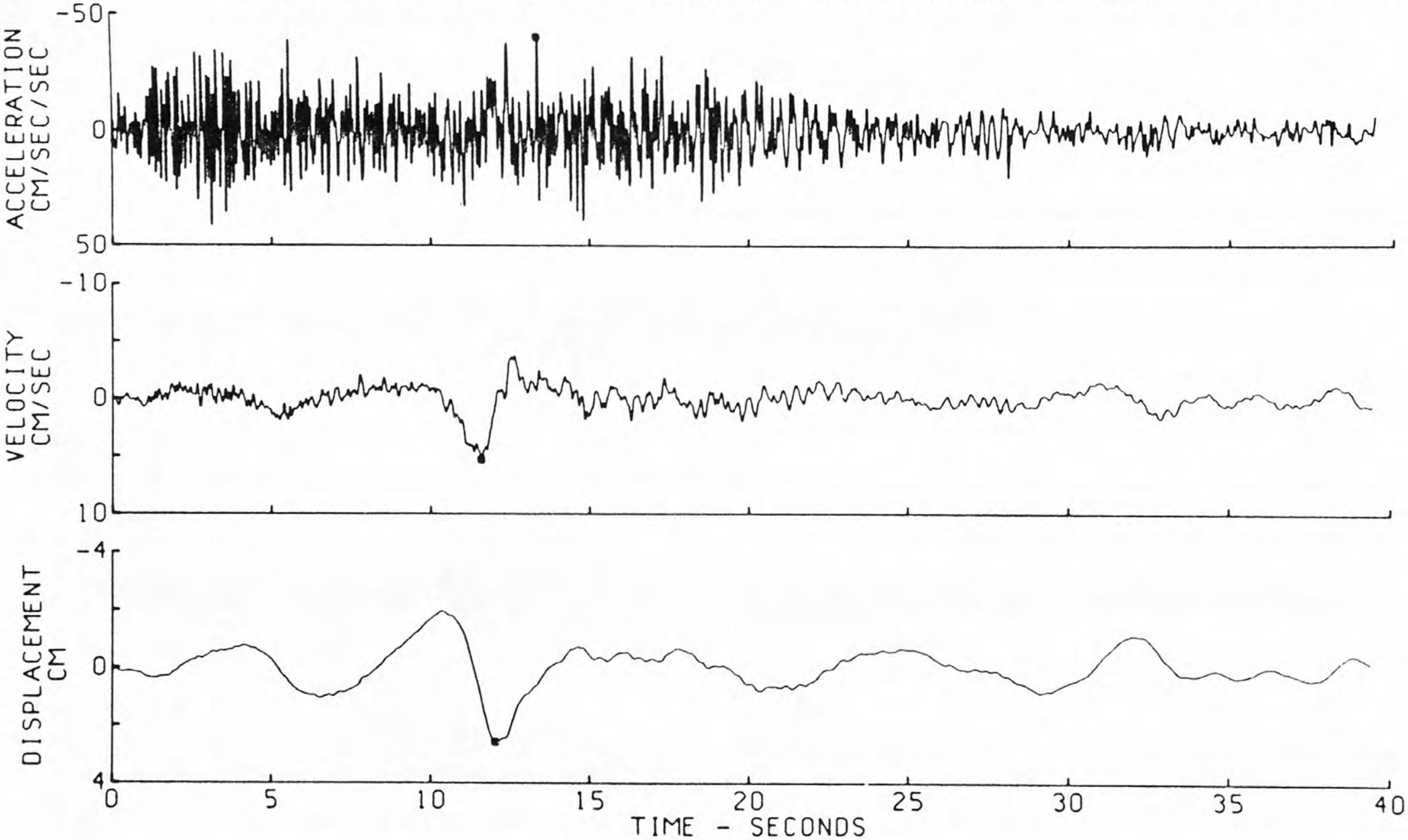

LIMA, PERU, LA MOLINA STATION, 11/9/74
L
V
T
ACCELERATION IN G/10
2
1
0
-1
-2
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
TIME IN SECONDS


LIMA, PERU, LA MOLINA STATION, 11/9/74
L
V
T
ACCELERATION IN G/10
2
0
-2
30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
TIME IN SECONDS

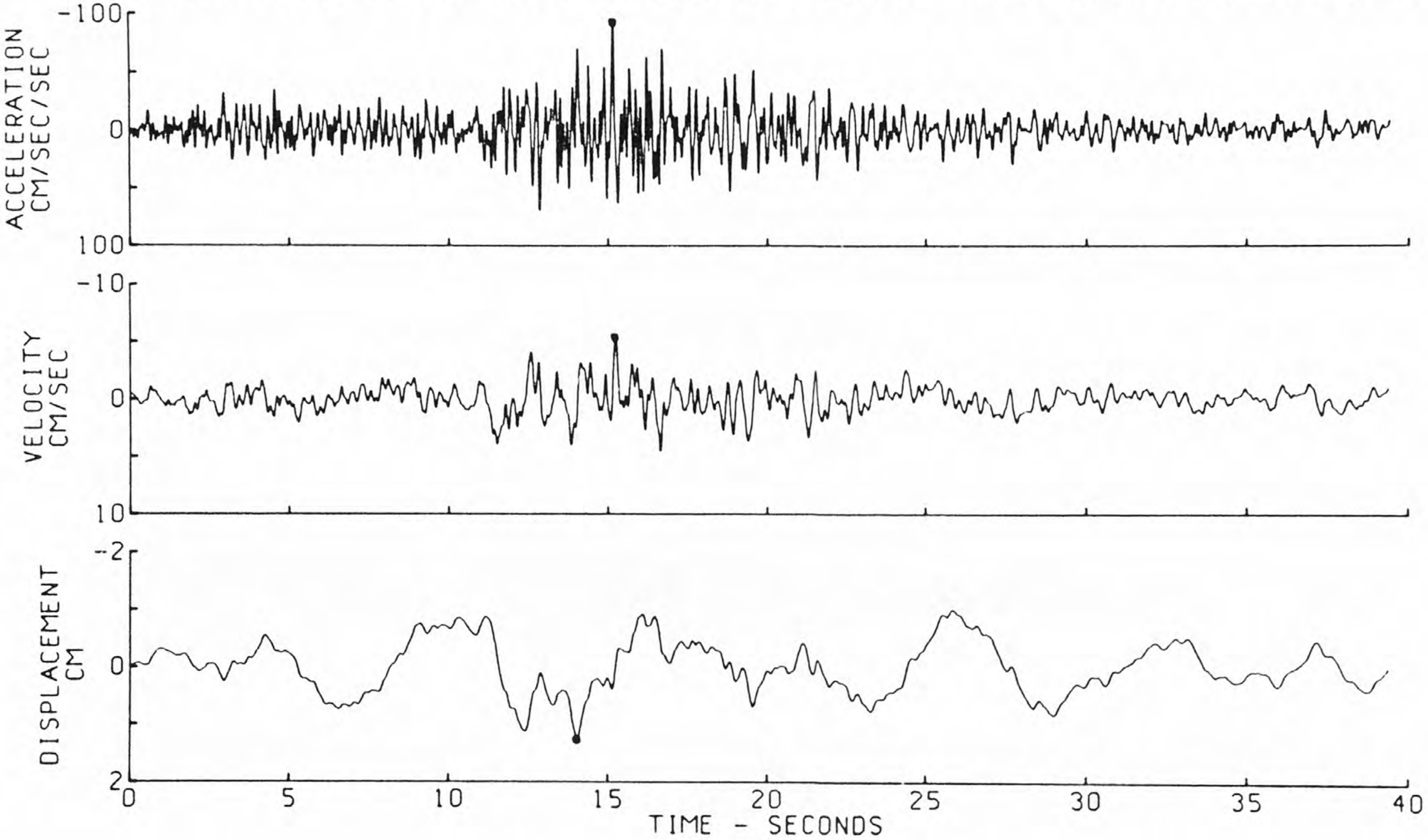
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF NOVEMBER 9, 1974
LA MOLINA STATION, L COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .090 - .125 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-116.8 CM/SEC/SEC, VELOCITY=-7.890 CM/SEC, DISPL=2.430 CM

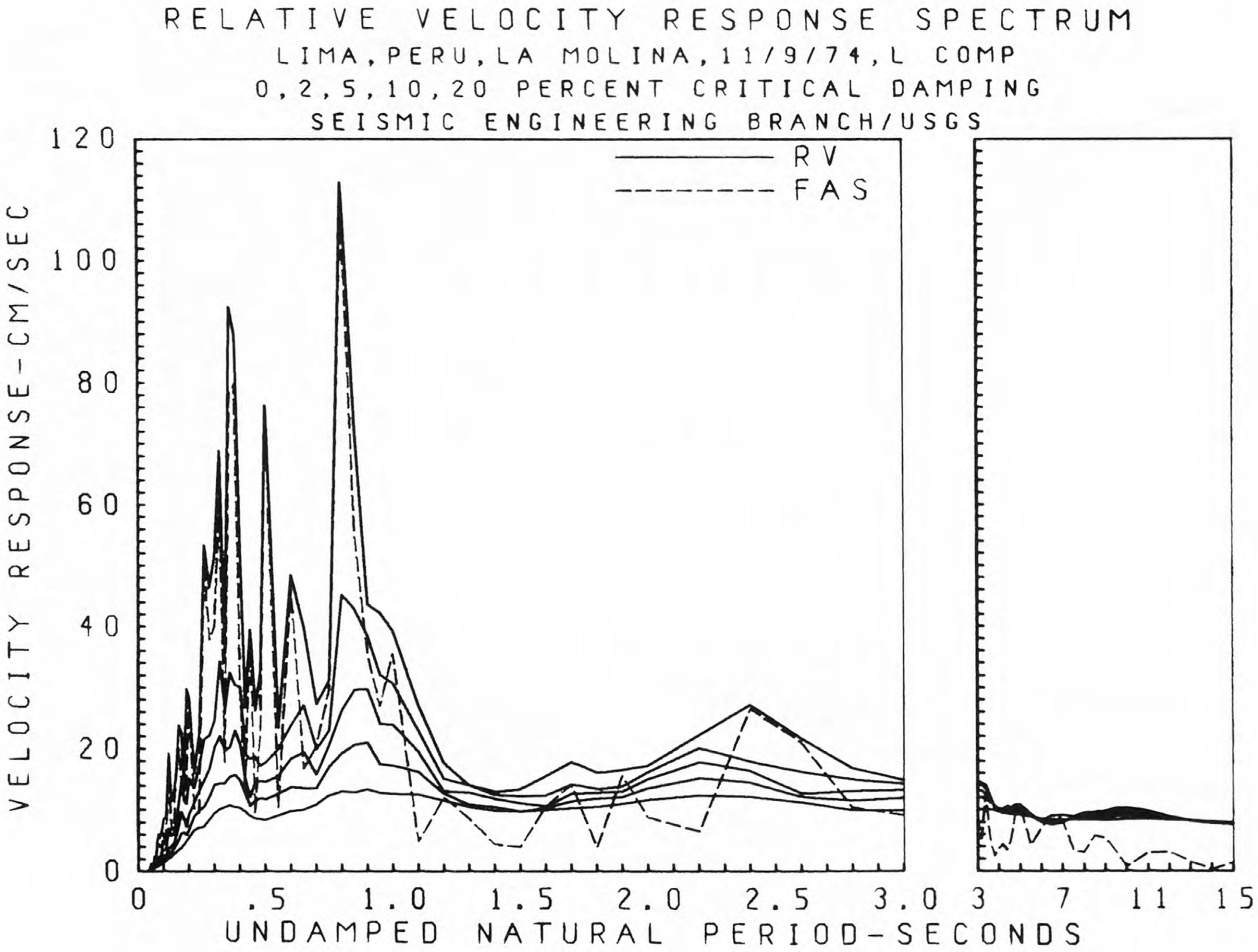


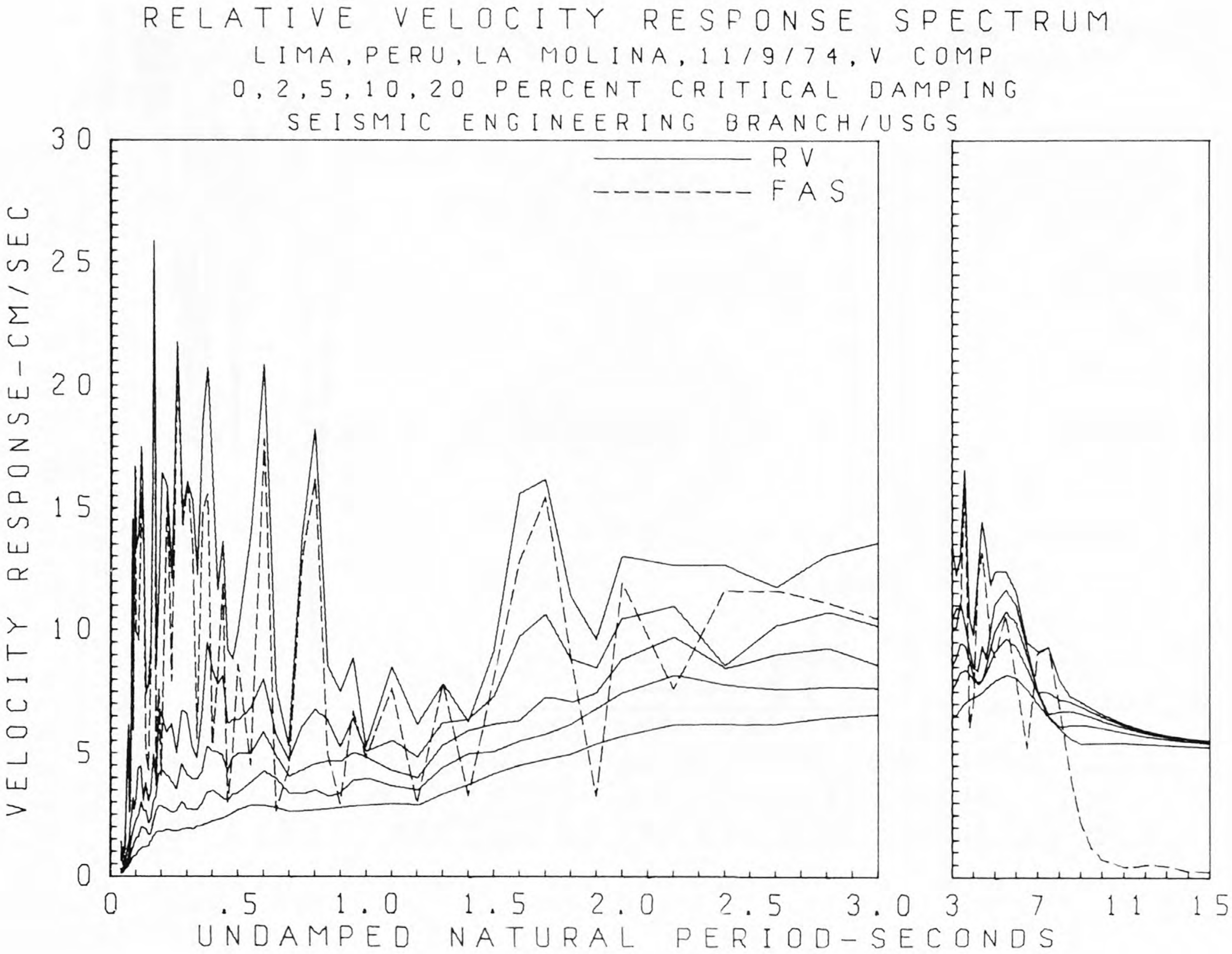
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF NOVEMBER 9, 1974
LA MOLINA STATION, V COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .090 - .125 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-41.26 CM/SEC/SEC, VELOCITY=5.330 CM/SEC, DISPL=2.590 CM

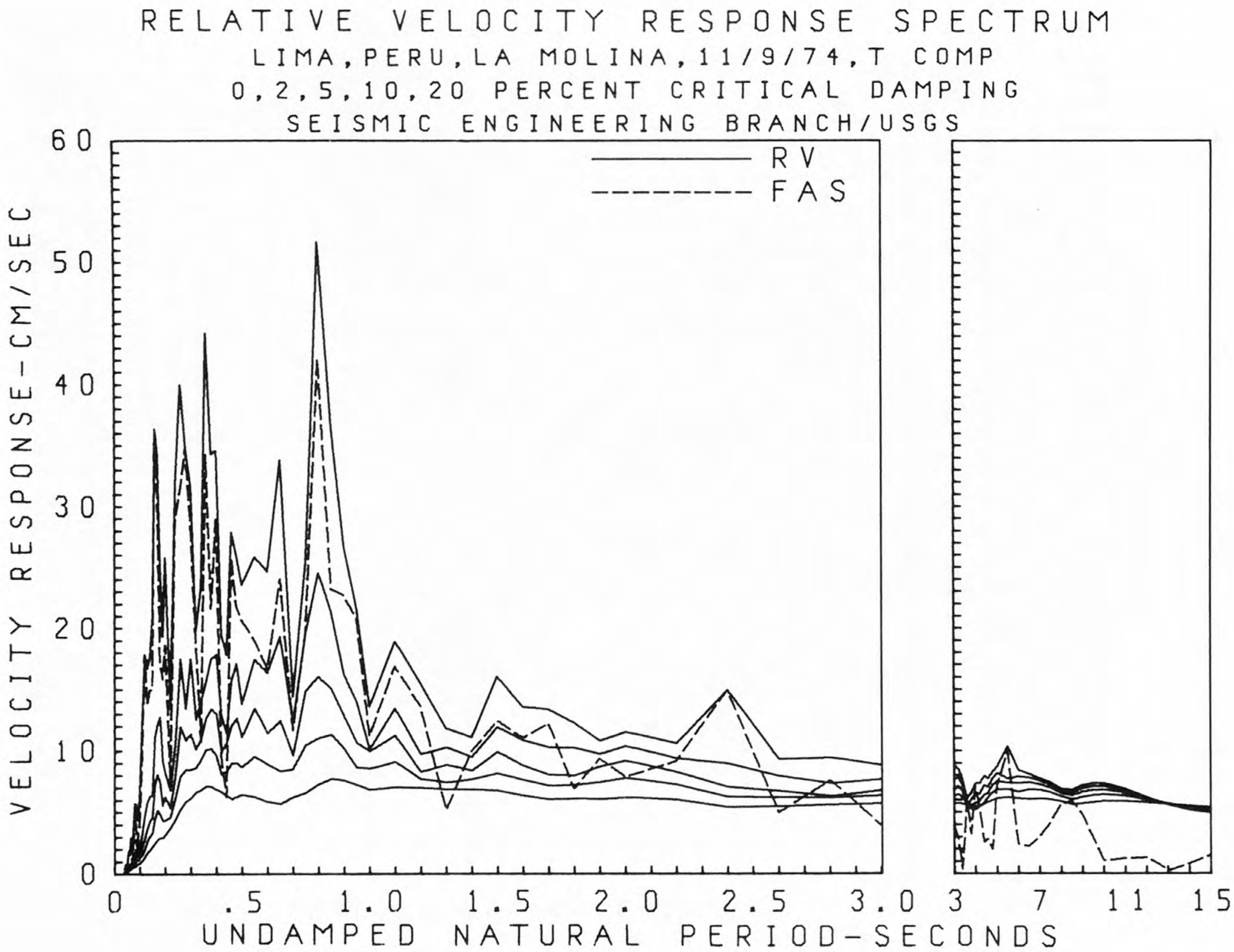


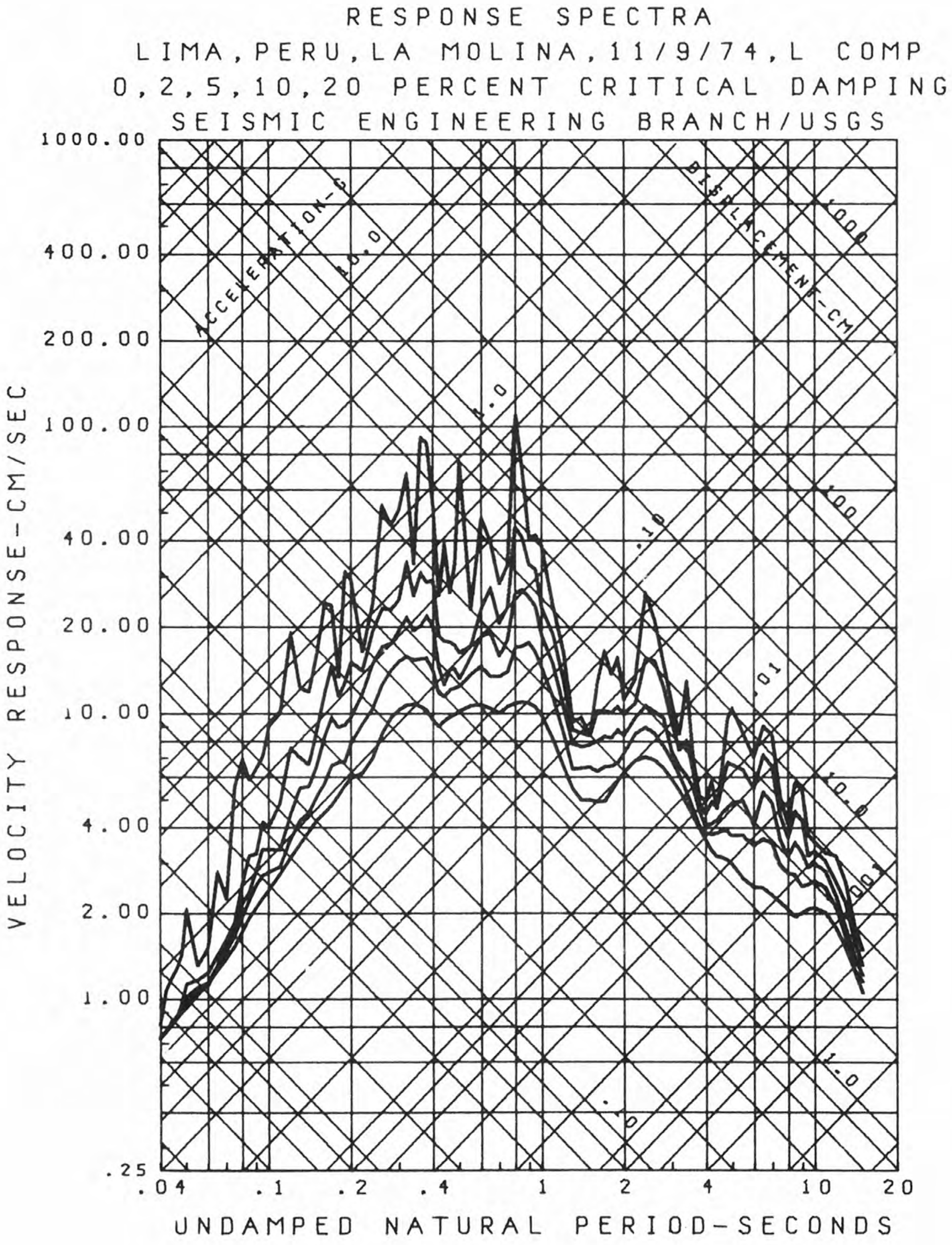
CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
LIMA, PERU EARTHQUAKE OF NOVEMBER 9, 1974
LA MOLINA STATION, T COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .090 - .125 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-93.71 CM/SEC/SEC, VELOCITY=-5.350 CM/SEC, DISPL=1.280 CM

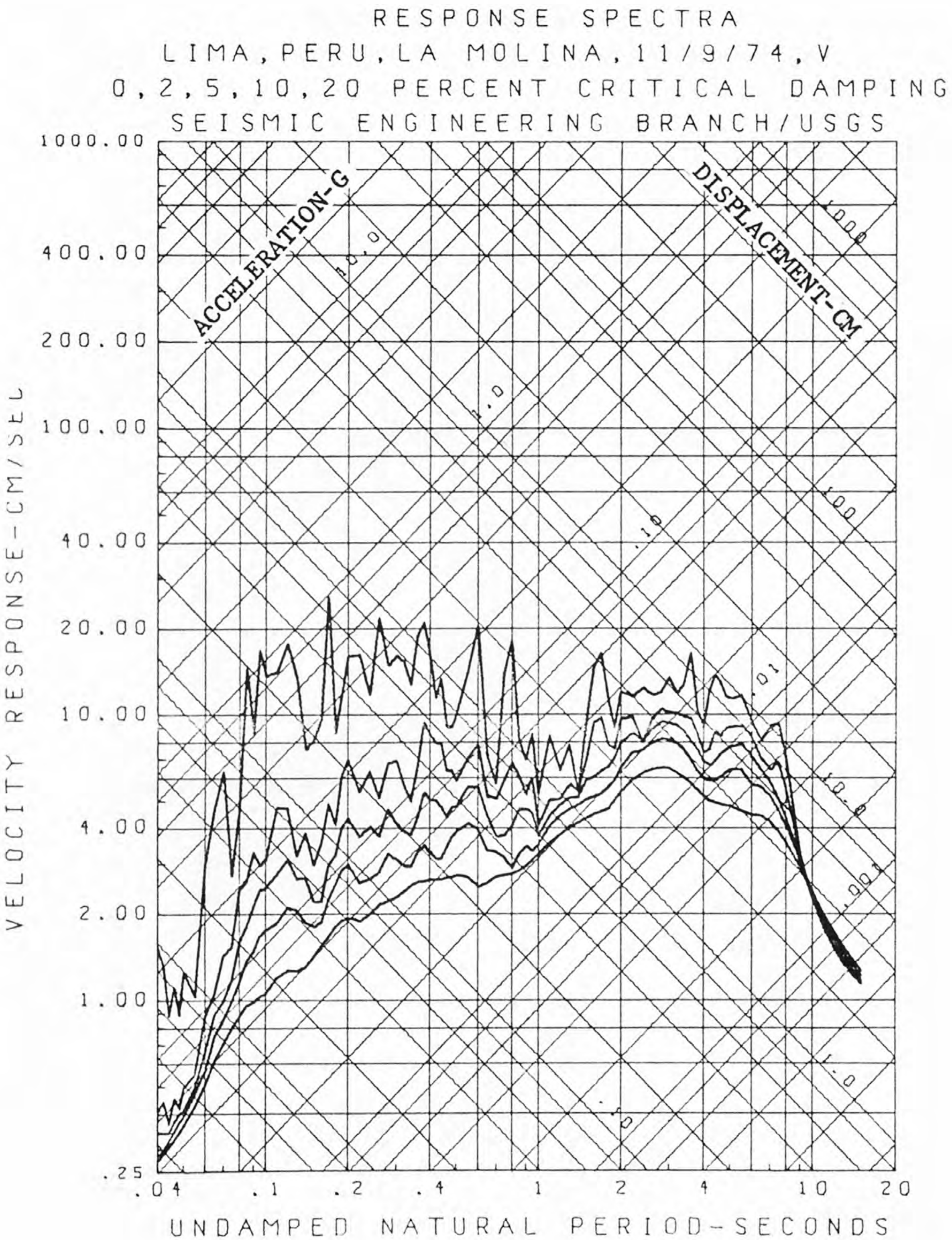


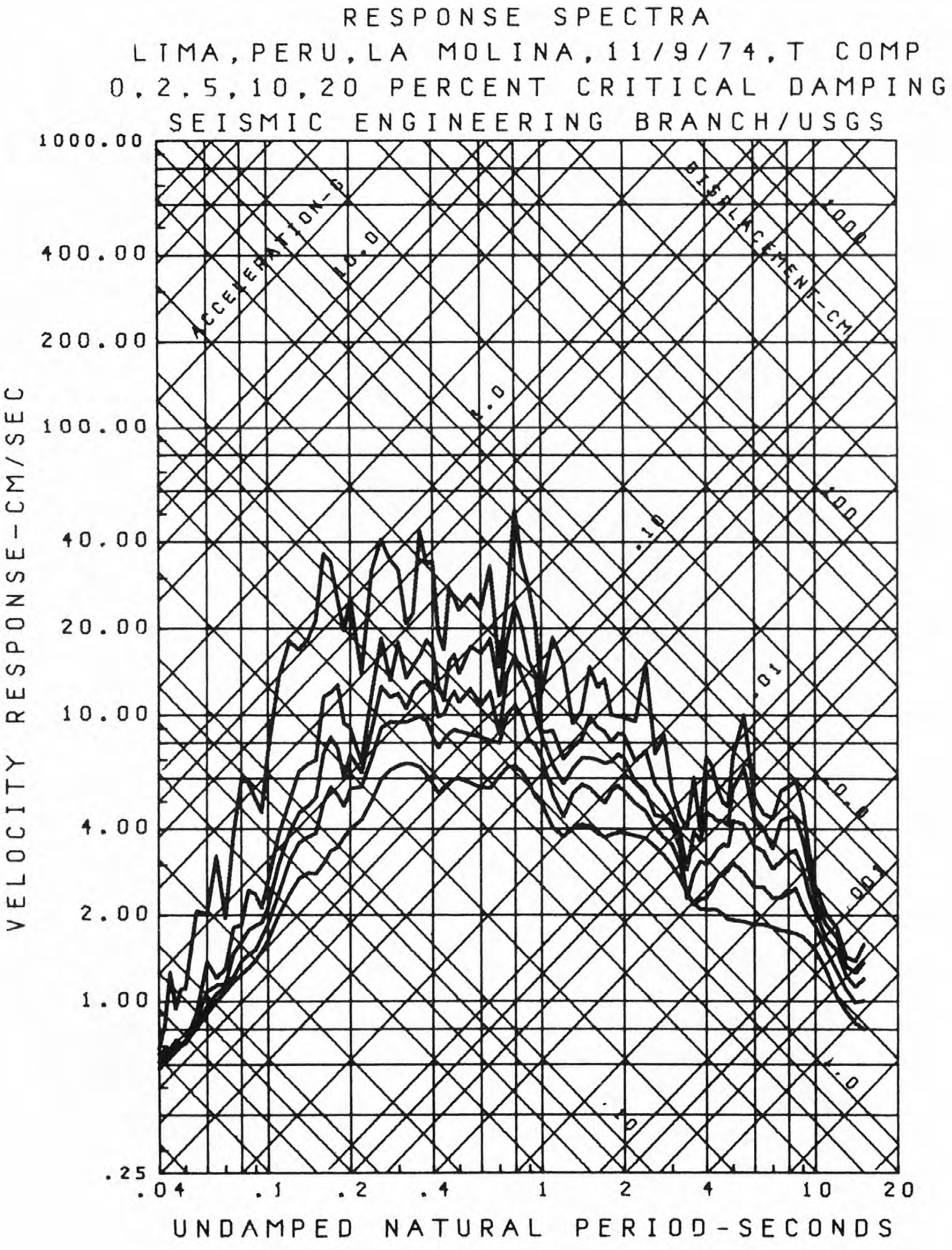

RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, LA MOLINA, 11/9/74, L COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
0
20
40
60
80
100
120
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

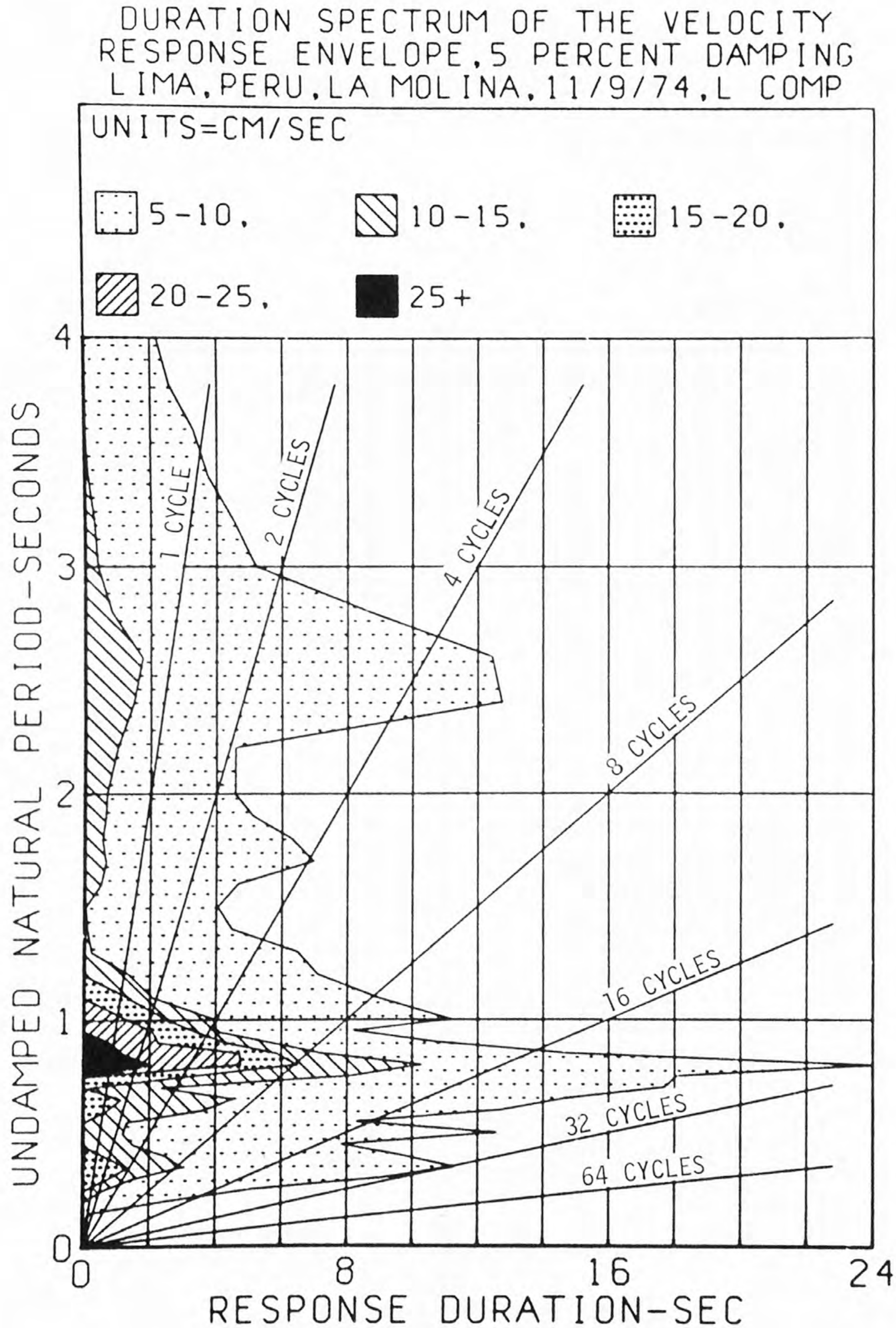

RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, LA MOLINA, 11/9/74, V COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
0
5
10
15
20
25
30
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

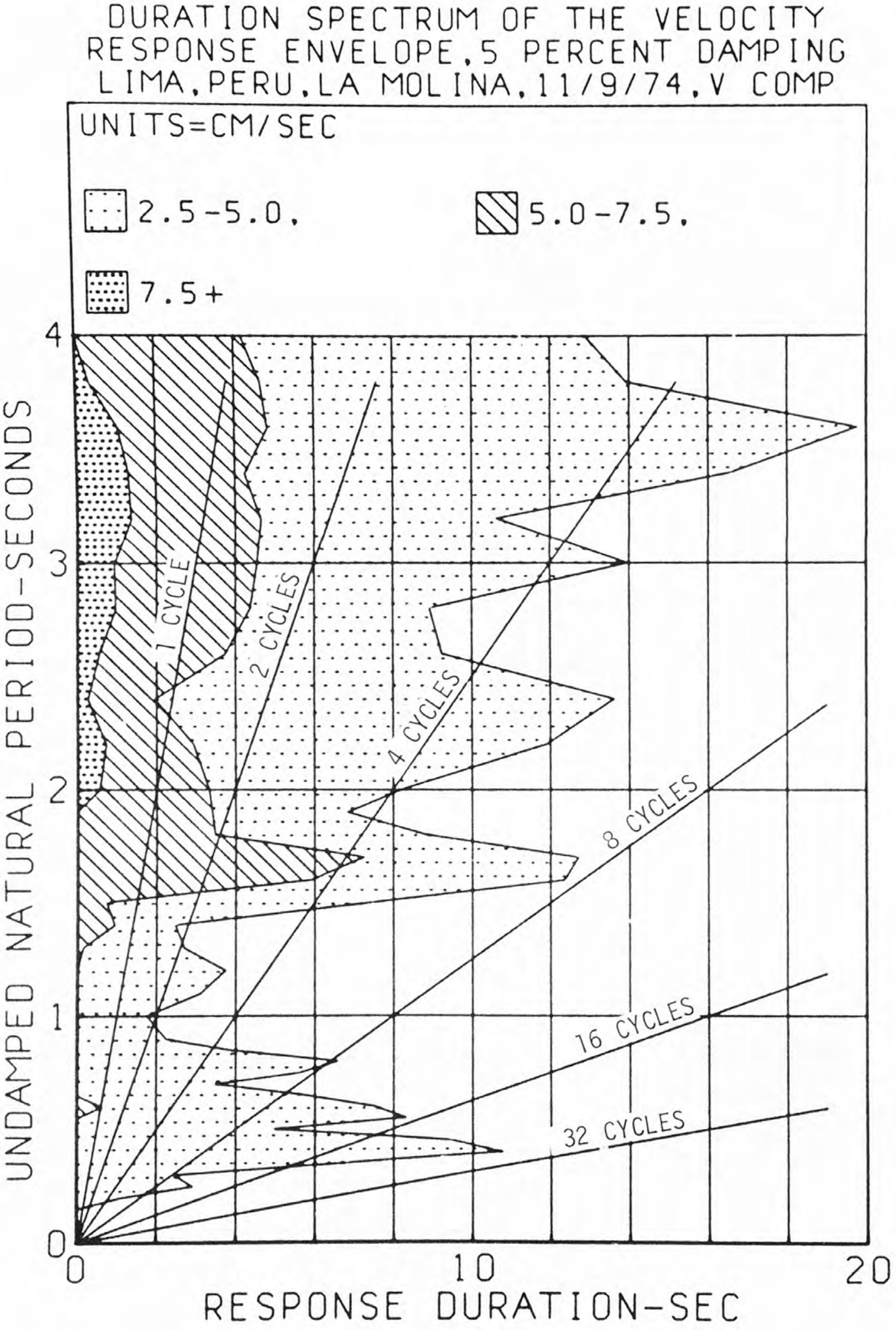

RELATIVE VELOCITY RESPONSE SPECTRUM
LIMA, PERU, LA MOLINA, 11/9/74, T COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
RV
FAS
VELOCITY RESPONSE-CM/SEC
0
10
20
30
40
50
60
0
.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIOD-SECONDS

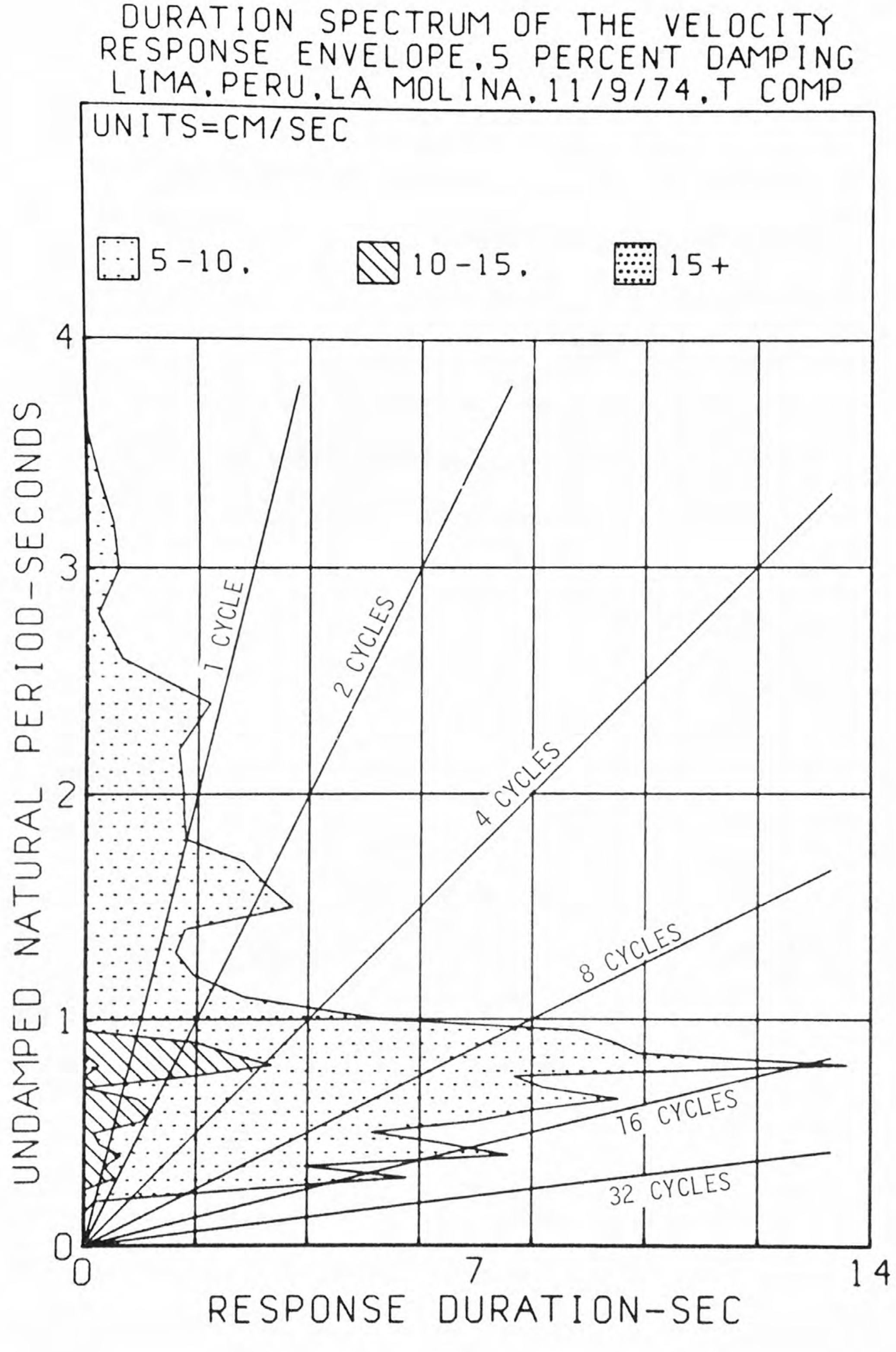

RESPONSE SPECTRA
LIMA, PERU, LA MOLINA, 11/9/74, L COMP
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
ACCELERATION-G
DISPLACEMENT-CM
UNDAMPED NATURAL PERIOD-SECONDS
.04
.1
.2
.4
1
2
4
10
20


RESPONSE SPECTRA
LIMA, PERU, LA MOLINA, 11/9/74, V
0, 2, 5, 10, 20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
ACCELERATION-G
DISPLACEMENT-CM
VELOCITY RESPONSE-CM/SEC
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS


RESPONSE SPECTRA
LIMA,PERU,LA MOLINA,11/9/74,T COMP
0,2,5,10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
.04
.1
.2
.4
1
2
4
10
20


DURATION SPECTRUM OF THE VELOCITY RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, LA MOLINA, 11/9/74, L COMP
UNITS=CM/SEC
5-10.
10-15.
15-20.
20-25.
25+
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
64 CYCLES
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
0
1
2
3
4
0
8
16
24


DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, LA MOLINA, 11/9/74, V COMP
UNITS=CM/SEC
2.5-5.0,
5.0-7.5,
7.5+
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
UNDAMPED NATURAL PERIOD-SECONDS
0
1
2
3
4
0
10
20
RESPONSE DURATION-SEC


DURATION SPECTRUM OF THE VELOCITY
RESPONSE ENVELOPE, 5 PERCENT DAMPING
LIMA, PERU, LA MOLINA, 11/9/74, T COMP
UNITS=CM/SEC
5-10.
10-15.
15+
UNDAMPED NATURAL PERIOD-SECONDS
RESPONSE DURATION-SEC
1 CYCLE
2 CYCLES
4 CYCLES
8 CYCLES
16 CYCLES
32 CYCLES
0
1
2
3
4
0
7
14

AVAILABILITY OF DIGITAL DATA

This report contains only plots of the digital data and the analyses performed on the records. Additional copies are available from:

USGS Seismic Engineering Branch
345 Middlefield Road, MS 87
Menlo Park, CA 94025

The digital data, including stage 1 uncorrected accelerations, stage 2 corrected acceleration, velocity and displacement, and stage 3 response and Fourier spectra are available on magnetic tape, distributed by the Environmental Data Service, whose address is:

NGSDC, Code D62
EDS/NOAA
Boulder,CO 80302

Each tape contains all the digital data that corresponds to each of the published data reports, as in the following list:

Report No. 77-587	Tape No.	Description
Open file report 76-609	C1839	1971 records
Open file report	C949	Records from Lima, Peru: 1951 to 1974

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