**INTEGRATED VERIFICATION EXPERIMENT DATA
COLLECTED AS PART OF
THE LOS ALAMOS NATIONAL LABORATORY'S
SOURCE REGION PROGRAM**

APPENDIX E

LOCAL AND NEAR-REGIONAL SEISMIC DATA FOR IVEs

**C. L. Edwards
Diane F. Baker**

Geophysics Group EES-3
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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1. Introduction

The summary Integrated Verification Experiment (IVE) report (1993) by Tom Weaver of EES-3 provides the background information for the series of IVEs. Appendix E provides details of the regional seismic data collected as part of the Los Alamos National Laboratory (LANL) Source Region Program. The goal was to obtain a better understanding of the effects of near-source phenomenology on far-field signals used for monitoring the testing limits of the Threshold Test Ban Treaty. Specifically, we tried to determine if regional phases, with or without corrections for working point media or spallation effects, provide yield estimates with acceptable uncertainties.

2. Approach

When acquiring regional seismic data, careful selection of hard-rock sites was paramount to reducing the ground-motion amplitude scatter typical of network data sets. In spite of this cautious approach to siting stations, the scatter of the observed amplitudes was unacceptably large, and so we tried measurements of the near-total-wave trains to bring the range of estimates for any given explosion down to more acceptable levels.

Most of our field deployments for recording seismic signals from NTS events at local and near-regional distances were toward the east along a profile that passes by the LANL infrasound array site at St. George, Utah, and continues by the Lawrence Livermore National Laboratory (LLNL) seismic station at Kanab, Utah (Fig. 1). The Sandia National Laboratories (SNL) seismic station at Leeds, Utah is between St. George and Kanab. Typically, four to six stations were set up to record intermediate-period data, and four to eight stations were set up to record the high-frequency data. Intermediate-period seismic stations, high-frequency seismic stations, and infrasound arrays of stations were collocated whenever possible to maximize the data acquired with the manpower and equipment resources available. In some instances the sample rates and the configuration of the recording systems were varied in order to accommodate the various sensors at a particular site.

3. Instrumentation system

We used two types of instrumentation for recording the regional seismic waves: high-frequency and intermediate-period systems. The high-frequency system records acceleration to a corner frequency at approximately 25 Hz and records velocity at higher frequencies. The intermediate period system records velocity at frequencies above the seismometer period of 5 s. All of the recordings were made with the seismometers placed on the surface and were on bedrock if there was any to be found in the vicinity.

The use of two different seismic systems accomplished two things. One is that there is usually redundancy with a slow sample rate for the intermediate period system, which can run

Figure 1. Station location map

for a long period of time and still be running when the shot is fired after weather-related delays. The short recording duration for the high-frequency system caused us to miss some events because communications were not available at the recorder sites and the information from telephones, tens of minutes away, amounted to predicted times or postshot confirmation. The other thing that two systems provided was greater resolution across the seismic band. The dynamic range of our recording system was too narrow for broadband recording with a single seismometer.

The high-frequency system used a Mark Products L4-3D seismometer (1-Hz natural frequency) with a signal-conditioning system that provided a band-pass filter with corners at 25 and 100 Hz. Three-component data were taken on virtually all high-frequency sites. The recording was done on Kinometrics portable digital recorders (PDR-2s) with GOES clocks to ensure accurate timing.

The intermediate-period system used the Kinometrics SV-1 and SH-1 seismometers (5-s natural period), and a Kinometrics signal conditioner with a low-pass corner at 1 Hz. At most sites only a vertical and a radial seismometer were installed. Three-component data were taken at only one or two sites for each IVE. The recording of these signals was also done on Kinometrics portable digital recorders with GOES clocks to ensure accurate timing.

4. Presentation of Data

In Table 1 is the full list of stations occupied for all IVEs. In this table, each IVE entry has a header with shot name, zero time, and seismic magnitude (as reported in the PDEs). This information is followed by the individual station data, including station name, station location, type of measurements made/component measured (where Z is the vertical, R is the radial, and T is the transverse), and range to the explosion in kilometers.

The pick times of the first arrival at each station fielded for each event are given in Table 2. In this table the entries are sorted by increasing range from the IVE source location. In column 1, the file names of the high-frequency records are defined as NNSSC where NN is the IVE name, SS is the station name, C is the component (Z,R,T), and the file names of the intermediate period records are defined as NSSC where N is the shortened IVE name, SS is the station name, and C is the component (Z,R,T). Column 2 gives the great circle range to the IVE source. Column 3 gives the pick time of the first arrival. The resulting time-distance plot in Fig. 2 shows that the velocity out to 115 km is 5.88 km/s, and the velocity from 115 to beyond 40 km is 7.58 km/s. In a few instances the times as recorded by the Kinometrics PDR-2s were incorrect. For signals displayed in the section plots and the Addendum, the times were corrected using the travel time curve.

The section plots of the regional seismic data in Figs. 3 and 4 were plotted with a reducing velocity of 7.58 km/s. Figure 3 has section plots of the vertical and radial components of the intermediate period data on the left and a filtered version of the same data on the right to

Figure 2. Time-distance plot of first arrivals

TABLE 1. Station information

TEXARKANA (TX)		ZERO TIME 041-20:06:00.055 1989	Seismic Magnitude 5.2
Station Name	Station Location	Measurements	Range (km)
CM (Cherokee Mine)	37.2672 -114.3686	T,R,Z (HF)	146.49
LM (Lime Mountain)	37.1838 -114.1556	R,Z (IP) T,R,Z (HF)	164.39
HD (Hildale)	37.0043 -112.9788	R,Z (IP) T,R,Z (HF)	268.98
FR (Fredonia)	36.8963 -112.4998	T,R,Z (HF)	312.33
KA (Kaibab)	36.8492 -112.2533	R,Z (IP) T,R,Z (HF)	334.68
INGOT (IN)		ZERO TIME 068-14:05:00.086 1989	Seismic Magnitude 5.0
Station Name	Station Location	Measurements	Range (km)
LM (Lime Mountain)	37.1838 -114.1556	R (IP),	169.84
HD (Hildale)	37.0043 -112.9788	R,Z (IP), T,R,Z (HF)	275.07
TULIA (TU)		ZERO TIME 146-18:07:00.021 1989	Seismic Magnitude --
Station Name	Station Location	Measurements	Range (km)
MP (Medsger Pass)	37.2394 -115.1964	R,Z (IP), T,R,Z (HF)	78.16
DM (Delamar)	37.3506 -114.8000	R,Z (IP), T,R,Z (HF)	115.22
LM (Lime Mountain)	37.1838 -114.1556	R,Z (IP), T,R,Z (HF)	169.15
HD (Hildale)	37.0043 -112.9788	R,Z (IP), T,R,Z (HF)	273.84
HR (House Rock)	36.7633 -112.0950	R,Z (IP), T,R,Z (HF)	354.67
MC (Marble Canyon)	36.8600 -111.6225	R,Z (IP), T,R,Z (HF)	395.50
CONTACT (CO)		ZERO TIME 173-21:15:00.083 1989	Seismic Magnitude 5.3
Station Name	Station Location	Measurements	Range (km)
CM (Cherokee Mine)	37.2672 -114.3686	R,Z (IP), T,R,Z (HF)	181.29
LM (Lime Mountain)	37.1838 -114.1556	R,Z (IP), T,R,Z (HF)	200.55
HD (Hildale)	37.0043 -112.9788	Z,R,Z (IP), T,R,Z (HF)	306.59
HR (House Rock)	36.7633 -112.0950	R,Z (IP), T,R,Z (HF)	388.41
AMARILLO (AM)		ZERO TIME 178-15:30:00.020 1989	Seismic Magnitude 4.9
Station Name	Station Location	Measurements	Range (km)
DM (Delamar)	37.3320 -114.7783	T,R,Z (HF)	139.81
CM (Cherokee Mine)	37.2672 -114.3686	R,Z (IP), T,R,Z (HF)	176.08
LM (Lime Mountain)	37.1838 -114.1556	R,Z (IP), T,R,Z (HF)	195.34
HD (Hildale)	37.0043 -112.9788	R,Z (IP), T,R,Z (HF)	301.37
HR (House Rock)	36.7633 -112.0950	R,Z (IP), T,R,Z (HF)	383.21
HORNITOS (HO)		ZERO TIME 304-15:00:00.085 1989	Seismic Magnitude 5.7
Station Name	Station Location	Measurements	Range (km)
LM (Lime Mountain)	37.1838 -114.1556	R,Z (IP), T,R,Z (HF)	207.45
HD (Hildale)	37.0043 -112.9788	R,Z (IP)	313.40

TABLE 1. Station Information (continued)

METROPOLIS (ME)		ZERO TIME 069-16:00:00.083 1990	Seismic Magnitude 5.0
Station Name	Station Location	Measurements	Range (km)
MP (Medsgar Pass)	37.2394 -115.1964	T,R,Z (HF)	77.55
DM (Delamar)	37.3506 -114.8000	R,Z (IP), T,R,Z (HF)	114.48
MV (Meadow Valley)	37.2851 -114.5628	R,Z (IP), T,R,Z (HF)	133.87
BN (Blue Nose)	37.2062 -114.2809	R,Z (IP), T,R,Z (HF)	157.95
LM (Lime Mountain)	37.1838 -114.1556	R,Z (IP), T,R,Z (HF)	168.94
HD (Hildale)	37.0043 -112.9788	R,Z (IP), T,R,Z (HF)	273.90
BULLION (BU)		ZERO TIME 164-16:00:00.008 1990	Seismic Magnitude 5.7
Station Name	Station Location	Measurements	Range (km)
4CU (NTS Ue4C Up)	37.0967 -116.0612	T,R,Z (SP)	36.75
4CD (NTS Ue4C Down)	37.0967 -116.0612	T (HF), L,Z (EP)	36.75
MM (Mine Mountain)	36.9943 -116.1478	T,R,Z (HF)	38.29
PR (Paiute Ridge)	37.0194 -115.9750	T,R,Z (HF)	47.82
LM (Lime Mountain)	37.1838 -114.1556	R,Z (IP), T,R,Z (HF)	201.18
HS (Hurricane South)	37.0570 -113.3046	R,Z (IP)	277.69
HD (Hildale)	37.0043 -112.9788	Z (IP), T,R,Z (HF)	307.14
FR (Fredonia)	36.8963 -112.4998	R,Z (IP)	350.95
QS (Queen of Sheba)	36.4479 -106.0392	R,Z (IP)	929.80
BC (Borrogo Canyon)	36.1981 -105.6138	R,Z (IP)	972.03
MINERAL QUARRY (MQ)		ZERO TIME 206-15:00:00.057 1990	Seismic Magnitude 4.7
Station Name	Station Location	Measurements	Range (km)
EP (Echo Peak)	37.2339 -116.3056	T,R,Z (HF)	8.64
TL (Tippipah Limestone)	37.0988 -116.1486	R,Z (IP), T,R,Z (HF)	13.33
4C (NTS Ue4C Down)	37.0967 -116.0612	T,L,Z (HF)	18.28
BU (Bullion)	37.2694 -116.4144	R,Z (IP), T,R,Z (HF)	19.07
FS (Frenchman South)	36.7056 -115.9631	R,Z (IP), T,R,Z (HF)	59.97
MM (Mine Mountain)	36.9943 -116.1478	R,Z (IP), T,R,Z (HF)	24.32
PR (Paiute Ridge)	37.0194 -115.9750	R,Z (IP), T,R,Z (HF)	29.75
CS (Cane Springs)	36.8486 -116.0397	R,Z (IP), T,R,Z (HF)	42.69

Table 2. Pick times of first arrivals

FILE NAME	RANGE (KM)	PICK (S)	FILE NAME	RANGE (KM)	PICK (S)
MQEPZ	8.6	2.3	CCMZ	181.3	29.7
QTLZ	13.3	2.9	ALMZ	195.3	31.5
MQTLZ	13.3	2.7	COLMZ	200.6	31.9
MQ4CZ	18.4	9.9	CLMZ	200.6	32.1
QBUZ	19.1	4.5	BULMZ	201.2	32.3
MQBUZ	19.1	4.2	ULMZ	201.2	32.5
MQMMZ	24.3	4.4	HLMZ	207.5	32.1
QMMZ	24.3	4.6	HOLMZ	207.5	32.8
MQPRZ	29.8	5.3	XHDZ	269.0	40.7
QPRZ	29.8	5.6	TXHDZ	269.0	40.8
QCSZ	42.7	7.6	TUHDZ	273.8	41.3
MQCSZ	42.7	7.3	UHDZ	273.8	41.8
QA5Z	60.0	10.3	MEHDZ	273.9	41.3
MQIAZ	60.0	10.5	MHDZ	273.9	41.3
MEMPZ	77.6	15.5	IHDZ	275.1	41.6
TUMPZ	78.2	12.2	INHDX	275.1	41.4
TMPZ	78.2	12.3	UHSZ	277.7	42.4
MDVZ	114.5	20.6	AMHDZ	301.4	45.1
MEDVZ	114.5	20.7	AHDZ	301.4	45.0
TDMZ	115.2	20.1	COHDZ	306.6	45.7
TUDMZ	115.2	20.3	CHDZ	306.6	45.8
MMVZ	133.9	23.3	BUHDZ	307.1	46.0
MEMVZ	133.9	23.9	UHDZ	307.1	46.1
AMDSZ	139.8	24.8	TXFRZ	312.3	46.5
ADSZ	139.8	25.1	HHDX	313.4	46.8
TXCMZ	146.5	24.8	XKAZ	334.7	49.3
MEFNZ	157.8	25.5	TXKAZ	334.7	49.5
MBNZ	157.8	26.4	UFRZ	351.0	51.8
XLNZ	164.4	27.2	TUHRZ	354.7	51.9
TXLMZ	164.4	27.1	THRZ	354.7	52.7
MELMZ	168.9	27.3	AHRZ	383.2	56.5
MLMZ	168.9	28.0	AMHRZ	383.2	56.2
TULMZ	169.2	27.8	CHRZ	388.4	57.1
ULMZ	169.2	27.2	COHRZ	388.4	56.8
ILMZ	169.8	28.0	TUMCZ	395.5	57.8
INLMZ	169.8	27.7	UMCZ	395.5	58.8
AMCMZ	176.1	28.9	UQSZ	929.8	124.4
ACMZ	176.1	29.0	UBCZ	972.0	129.3

Figure 3. Section plots of intermediate-period seismograms

D

vertical component

radial component

C

vertical component

radial component

Figure 4. Section plots of short-period seismograms

Figure 5 Comparison of short period seismograms at Line Mountain

Figure 6. Comparison of intermediate period seismograms at Lime Mountain

Figure 7. Comparison of short period seismograms at Hildale

Figure 8. Comparison of intermediate period seismograms at Hildale

show the surface waves. Figure 4 has section plots of the vertical and radial components of the high-frequency data on the left and the same data on the right plotted at a different time scale to show more detail of the first 10-20 s of the signals. Data in which the signal-to-noise ratio was poor were deleted from the section plots. Section plots from multiple sources are difficult to interpret because energy partitioning is different with different source geometry (location vertically and laterally with respect to geologic discontinuities and stratigraphic variations), and probably is a function of source media out to several cavity radii and different near-surface geologic properties.

On each experiment we also repeated the measurements at two stations, Lime Mountain and Hildale, to compare in detail the propagating phases and codas at the same station location. Figure 5 shows the comparison plots of short-period measurements at Lime Mountain. Figure 6 shows the comparison plots of intermediate period measurements at Lime Mountain. Figure 7 shows the comparison plots of short-period measurements at Hildale. Figure 8 shows the comparison plots of intermediate period measurements at Hildale.

The plots of the raw data for each experiment and each station are given in the Addendum. The IVE name and the station name are given at the top of each plot. Three hundred seconds of data are plotted, with zero seconds on the plots defined as zero time of the experiment.

5. Additional Information

For additional information concerning these data sets you may contact:

Diane F. Baker
EES-3
Mail Stop C335
Los Alamos National Laboratory
Los Alamos, New Mexico 87545
Telephone (505) 665 3776

C. L. Edwards
EES-3
Mail Stop C335
Los Alamos National Laboratory
Los Alamos, New Mexico 87545
Telephone (505) 667-8464

6. Credits

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ADDENDUM Raw Data Plots

Key to interpretation:

1. The difference in Experiment Name, e.g., co vs c, is a two-letter abbreviation for Short Period and a one-letter abbreviation for Intermediate Period.
2. Zero time on the plots is zero time of the shot.
3. Data were recorded as velocity.
4. Component may be vertical (z), radial (r), or transverse (t).

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Fig. 61