ISEE SEISMOGRAPH FIELD COMPARISON STUDY

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DESA
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INTRODUCTION

The ISEE Seismograph Committee decided to run a field test comparison as part of its project to establish operational specifications for blasting seismographs and means to calibrate or certify their performance and accuracy.

Seismograph manufacturers or their representatives were invited to participate with the understanding that individual instruments would not be identified. Each participant would know which are his own records and be able to compare his to the collection of others. With data submissions through the ISEE office, even those doing the analyses (e.g., the authors above) would not know the origin of any individual submission.

PROCEDURES

General Provisions: A field test comparison was done at the Vulcan Materials Calera quarry near Birmingham, Alabama, March 24, 1997, following arrangements by McRoy Sauls. Two production blasts in different benches were monitored by over a dozen seismographs from six seismograph companies. With duplicate seismographs, some variations in procedures were tried, such as, depths of burial and microphone heights.

Two production blasts were detonated as follows:

Nominal times	Bench	Approximate PPV, in/sec	Approximate dominant frequency, Hz	Approximate airblast, dB
10:40	Lower	0.40	32-39	122
10:50	Upper	0.15	13-36	130

Field Procedures: Each participant installed his own seismograph transducer package (jug) with the provision that they would be buried at least flush with the ground. Most were completely buried with several inches of top soil over them. With different jug heights, there was no way they could all have the same depths for both top and bottom surfaces.

Longitudinal alignments were estimated as the blast bench could not be seen from the instrument location. Distances to the blasts were about 500 ft and the instrument "field" was about 20 feet wide. The benches being blasted were considerably lower than the one where the instruments were installed.

Waveform records from the test are identified by code letters assigned by the ISEE office: VV, TT, MM, PP, JJ, CC, FF and numbered to correspond to either blast #1 at 10:40 AM or #2 at 10:50 AM.

In addition to the instruments under test, DESA provided five seismographs of the same model (labeled with ID numbers 150, 187, 189, 461 and 780). Two different jug burial depths and microphone heights were used with these seismographs.

Analysis Procedures: Data collection and analyses proved far more difficult than anticipated and delayed this report by several months. Simple ASCII files were wanted with values of vibration in in/sec and airblast in psi or equivalent. Most files were not in absolute amplitude units and Stagg had to scale according to the reported peak particle velocities. One record of airblast was an ASCII file of dB values and many did not initially report time per point. One set of records, VV2, was received too late to be included with the others without rescaling all the other records or going to a legal page size. It was included as an additional plot. Some records were inverted relative to the majority, and had to be "flipped" . In one case, it was noticed after analysis that a flip wasn't made that should have been, 10:50 AM VV2 (next to last plot).

RESULTS

Comparisons are shown by 18 plots of vibration and airblast waveforms:

10:40 AM Longitudinal GV, instruments under test
10:40 AM Longitudinal GV, five seismographs from DESA
10:50 AM Longitudinal GV, instruments under test
10:50 AM Longitudinal GV, five seismographs from DESA

10:40 AM Vertical GV, instruments under test

10:40 AM Vertical GV, five seismographs from DESA
10:50 AM Vertical GV, instruments under test
10:50 AM Vertical GV, five seismographs from DESA

10:40 AM Transverse GV, instruments under test
10:40 AM Transverse GV, five seismographs from DESA
10:50 AM Transverse GV, instruments under test
10:50 AM Transverse GV, five seismographs from DESA

10:40 AM Airblast, instruments under test
10:40 AM Airblast, five seismographs from DESA
10:50 AM Airblast, instruments under test
10:50 AM Airblast, five seismographs from DESA

10:50 AM VV2 GV and AB Records
10:40 & 10:50 AM JJ Airblast Records

DT Froedge collected a near-surface soil sample and determined a specific gravity of 2.02. The general recommendation for jug density is that it should be no more than that of the soil it is in. Unfortunately, the jug densities are not known to the authors.

Discussion: The five DESA seismographs compared reasonably well although that does not automatically guarantee that they are accurate. Longitudinal and transverse components of motion generally showed consistent differences between those buried shallow and those at greater depth, but this was not so for verticals. Airblasts were also a good match with microphone heights apparently not having any influence. Waveforms were a good match as were peak values.

Among tested instruments, all of different manufacture, there were family resemblances. However, there were significant differences in both waveforms and peak values. For every combination of motion components and the two blasts, there are a few which appear greatly in error or at least different from the general "consensus". The JJ and VV airblasts (last plot) appear to be missing the low frequencies.

Some sources of error and reasons for differences are:

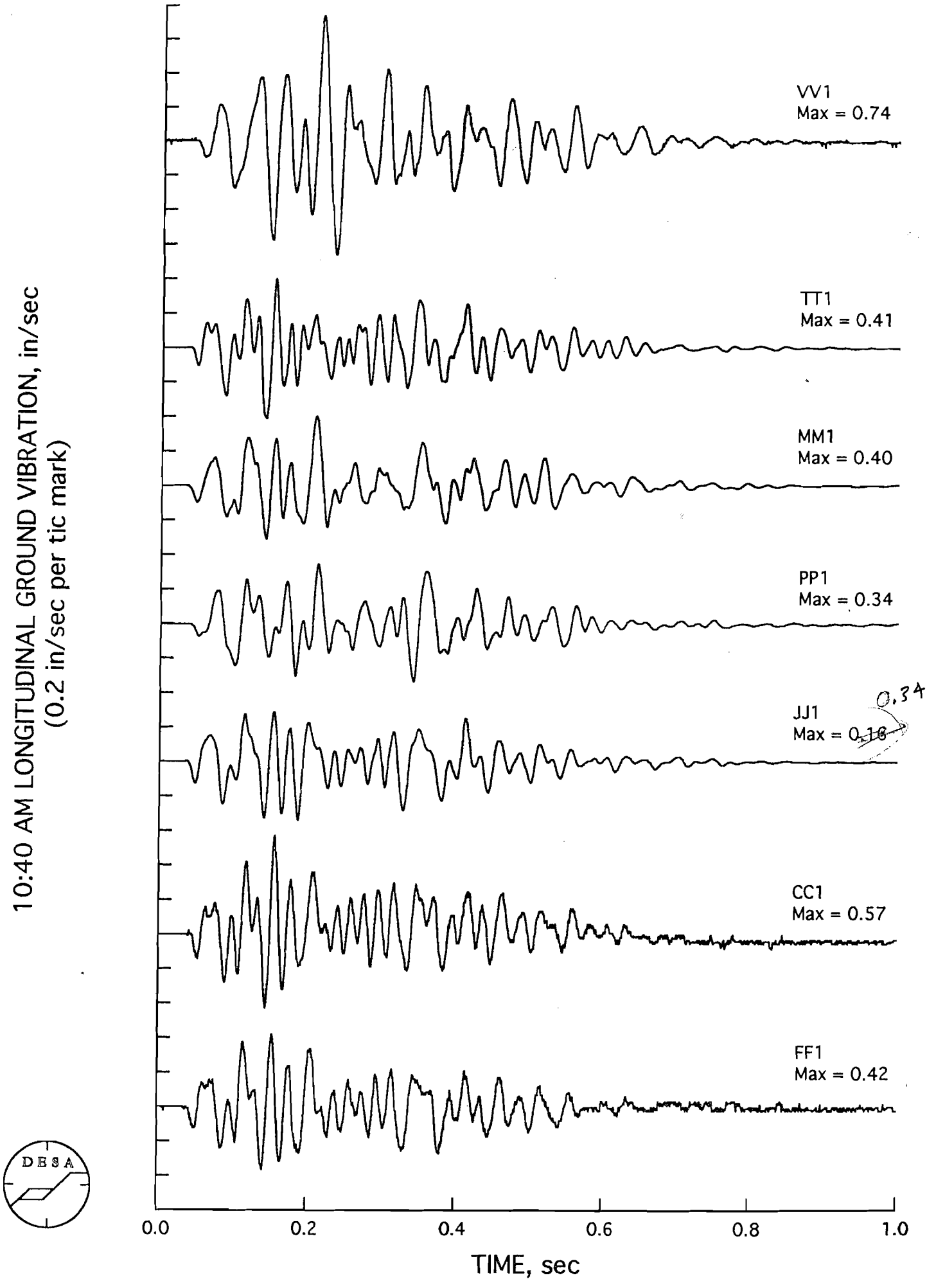
Depths of burial and soil variations in the test area
Alignment of the longitudinal arrow
Out of level

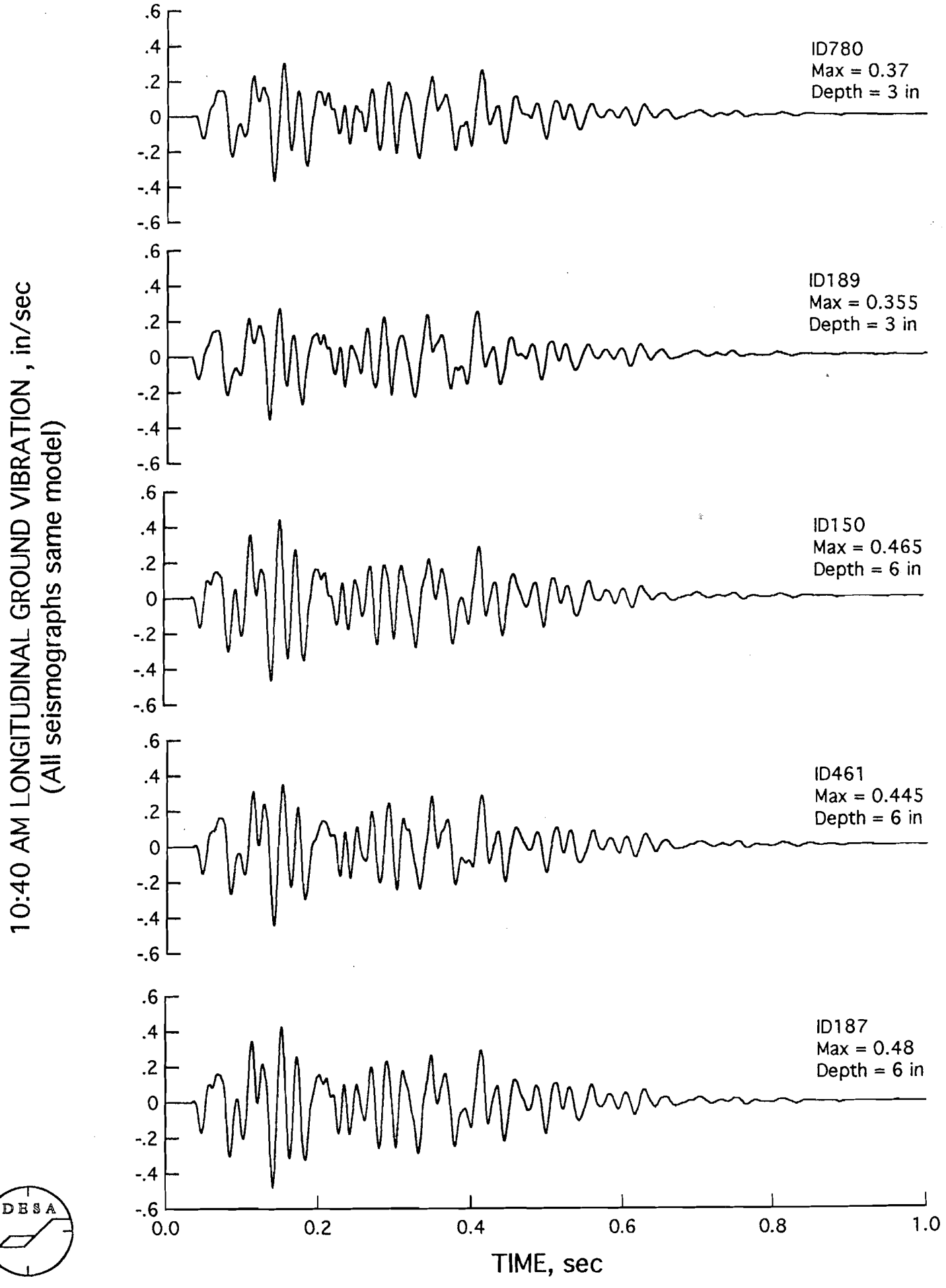
Different actual jug locations combined with high frequencies (phase differences affecting peaks)
Coupling effectiveness
Depths of burial
Errors in ASCII file submittals
Errors in analyses
Actual instrument problems

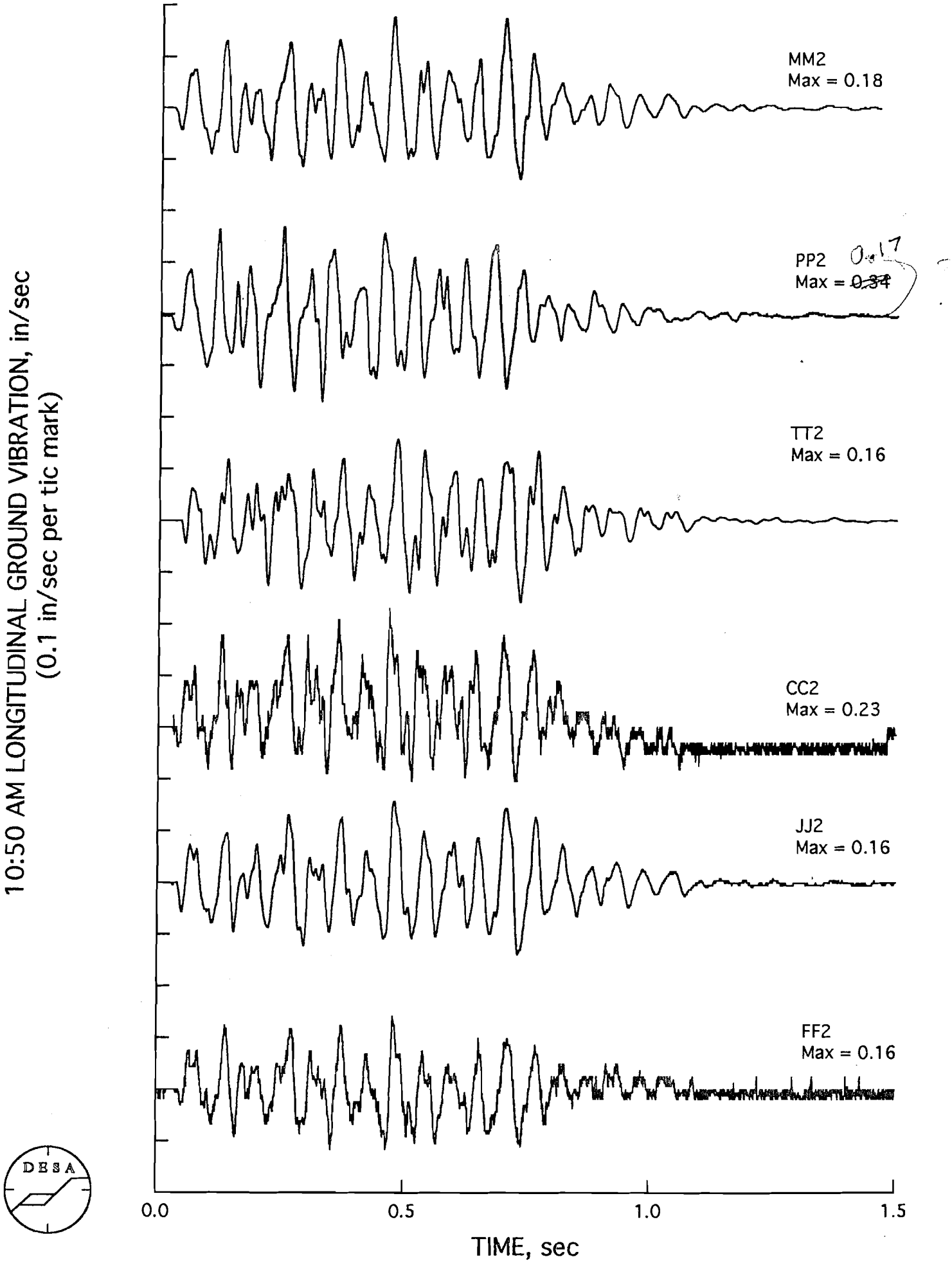
CONCLUSIONS

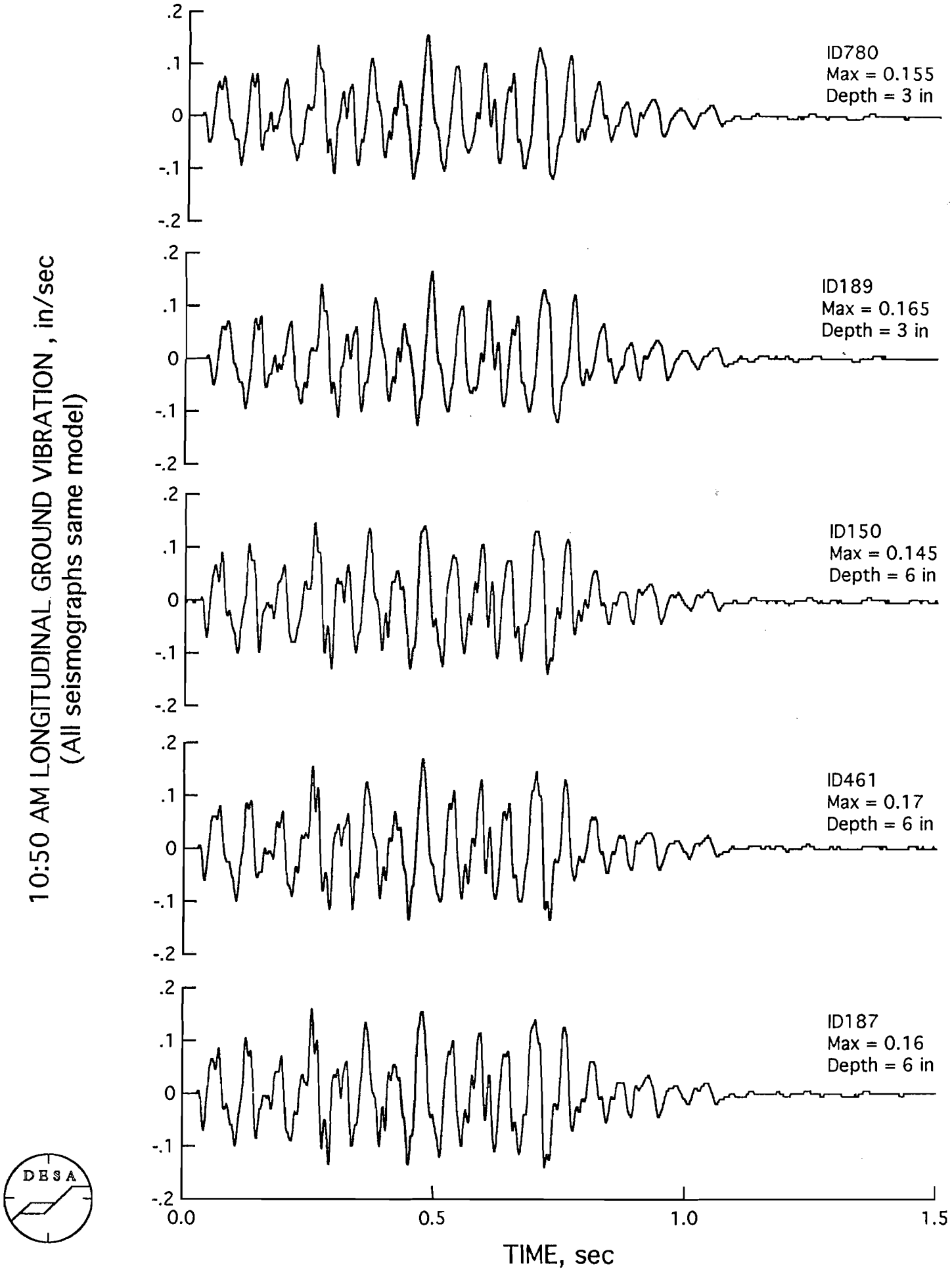
There are significant performance differences and they appear to be more than expected from variations in field practices. Unexpectedly high frequencies and correspondingly high accelerations for the test blasts increased the problems with good and consistent coupling. Peak values were affected by phase differences between instruments tens of feet apart. A few cases of "independent performance" justify a careful examination of instrument performance.

The need and interest for an additional field test should be considered. Procedures can be adjusted to reduce errors arising out of field practices. A site with a broader vibration frequency band could be sought and also one with thick uniform surface soil to provide a better medium for placement of the jug. After this analysis exercise, it is expected that all participants would be able to supply a reliable ASCII file with all the key information.


10:40 AM LONGITUDINAL GROUND VIBRATION, in/sec
(0.2 in/sec per tic mark)
VV1
Max = 0.74
TT1
Max = 0.41
MM1
Max = 0.40
PP1
Max = 0.34
JJ1
Max = 0.34
CC1
Max = 0.57
FF1
Max = 0.42
DESA
0.0
0.2
0.4
0.6
0.8
1.0
TIME, sec

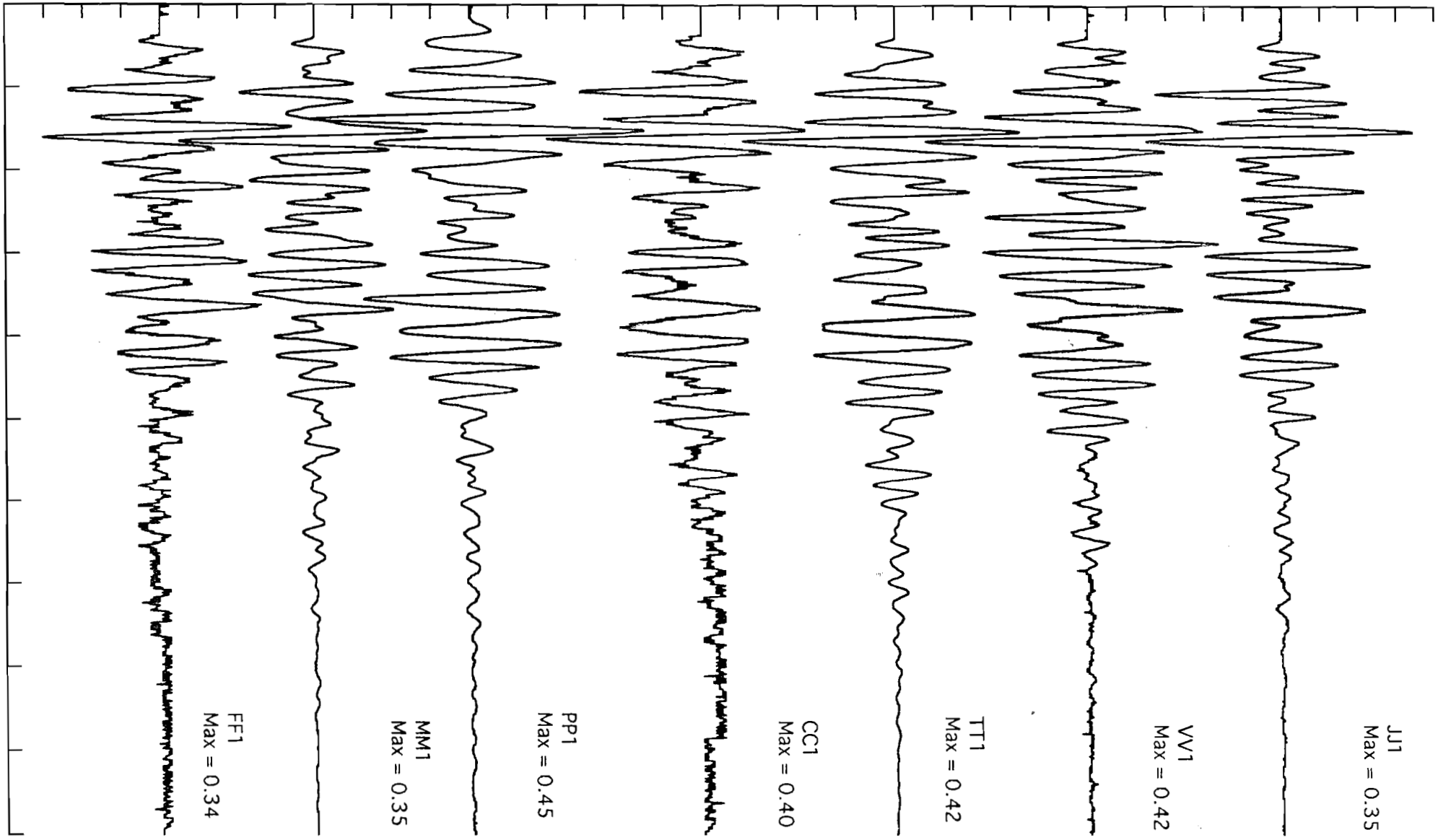

10:40 AM LONGITUDINAL GROUND VIBRATION , in/sec
(All seismographs same model)
ID780
Max = 0.37
Depth = 3 in
ID189
Max = 0.355
Depth = 3 in
ID150
Max = 0.465
Depth = 6 in
ID461
Max = 0.445
Depth = 6 in
ID187
Max = 0.48
Depth = 6 in
.6
.4
.2
0
-.2
-.4
-.6
0.0
0.2
0.4
0.6
0.8
1.0
TIME, sec
DESA

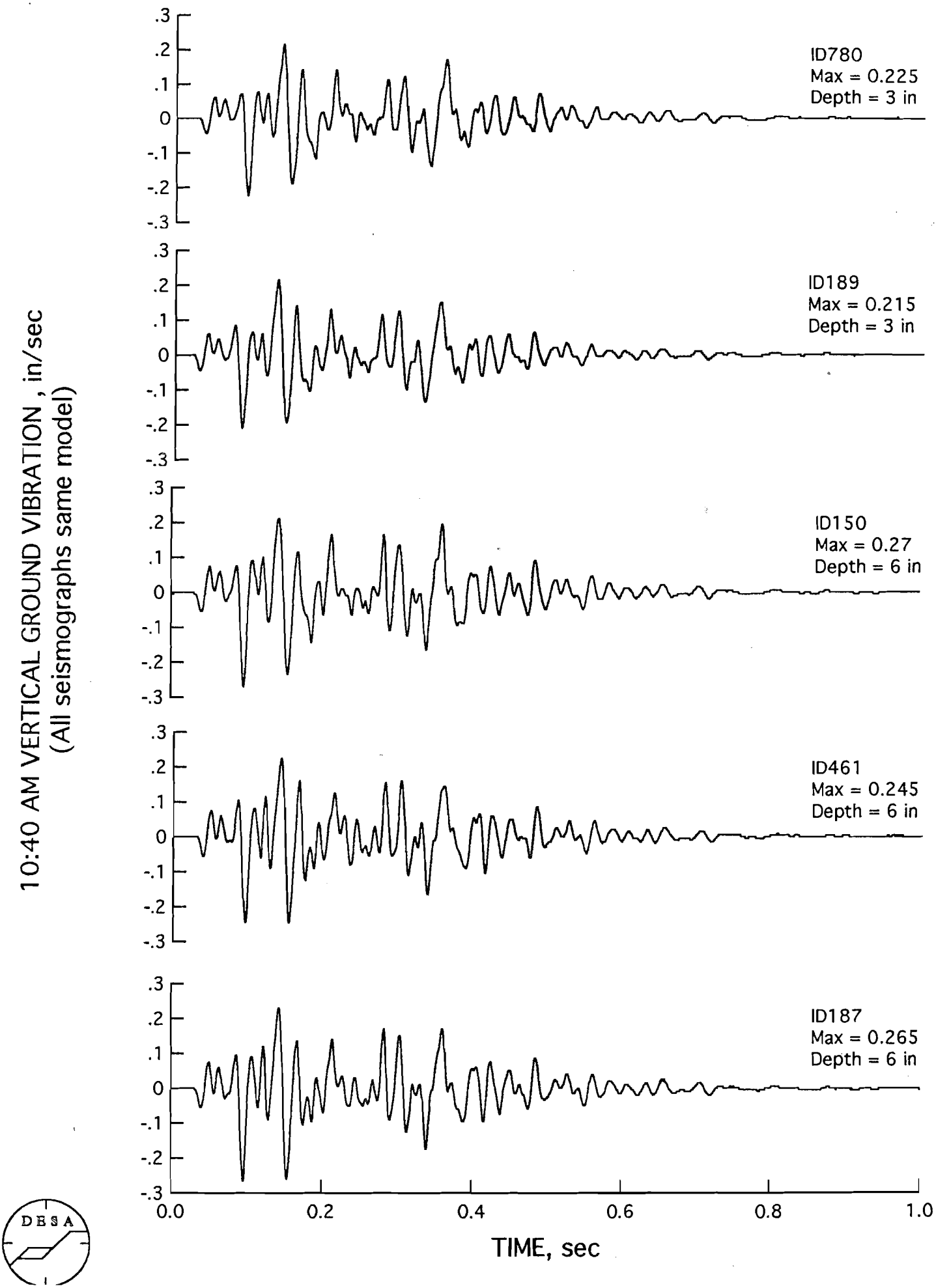

10:50 AM LONGITUDINAL GROUND VIBRATION, in/sec
(0.1 in/sec per tic mark)
MM2
Max = 0.18
PP2
Max = 0.34
0.17
TT2
Max = 0.16
CC2
Max = 0.23
JJ2
Max = 0.16
FF2
Max = 0.16
0.0
0.5
1.0
1.5
TIME, sec
DESA

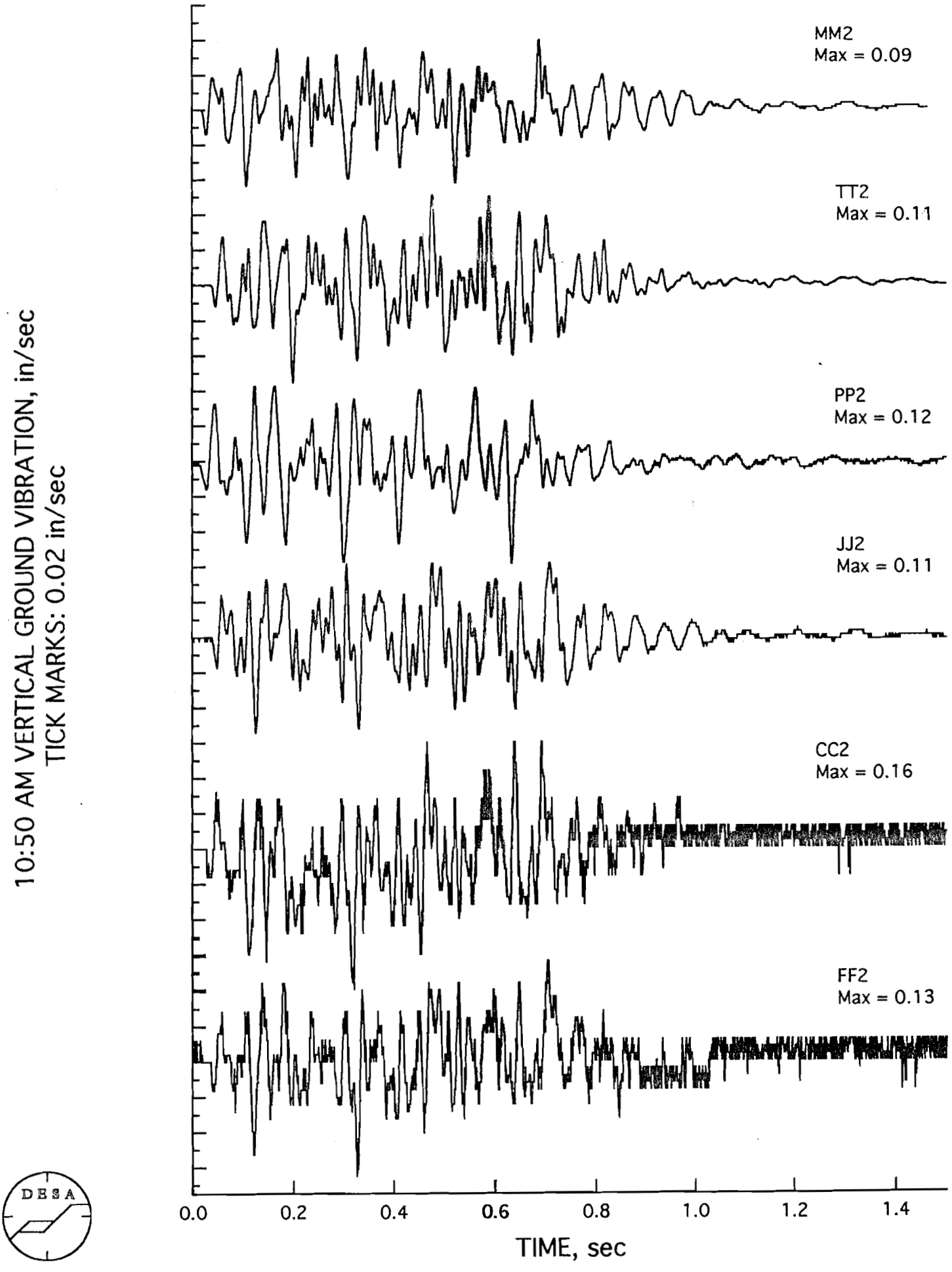

10:50 AM LONGITUDINAL GROUND VIBRATION , in/sec
(All seismographs same model)
.2
.1
0
-.1
-.2
ID780
Max = 0.155
Depth = 3 in
ID189
Max = 0.165
Depth = 3 in
ID150
Max = 0.145
Depth = 6 in
ID461
Max = 0.17
Depth = 6 in
ID187
Max = 0.16
Depth = 6 in
0.0
0.5
1.0
1.5
TIME, sec
DESA

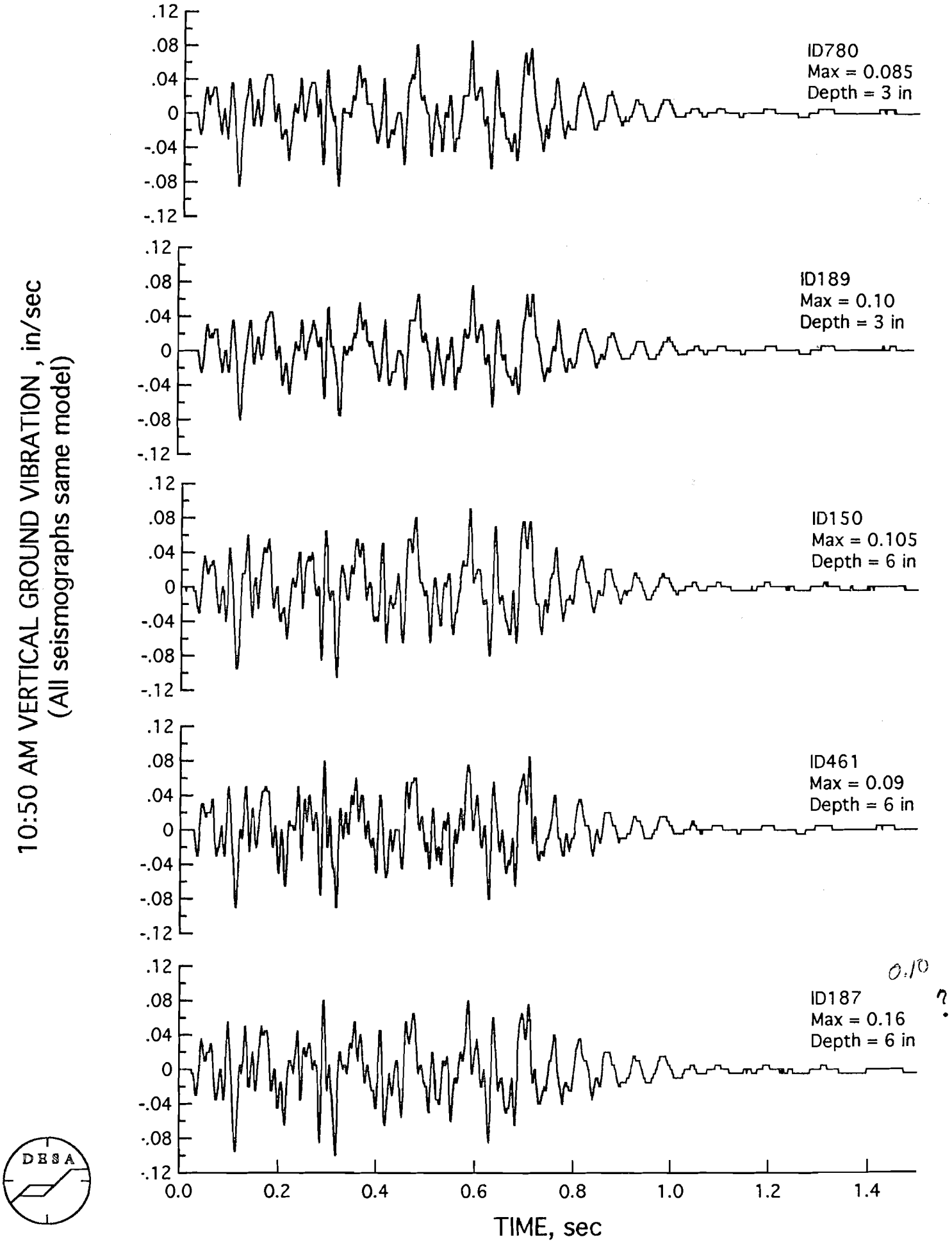
10:40 AM VERTICAL GROUND VIBRATION, in/sec

TICK MARKS: 0.1 in/sec vertical and 0.1 sec horizontal



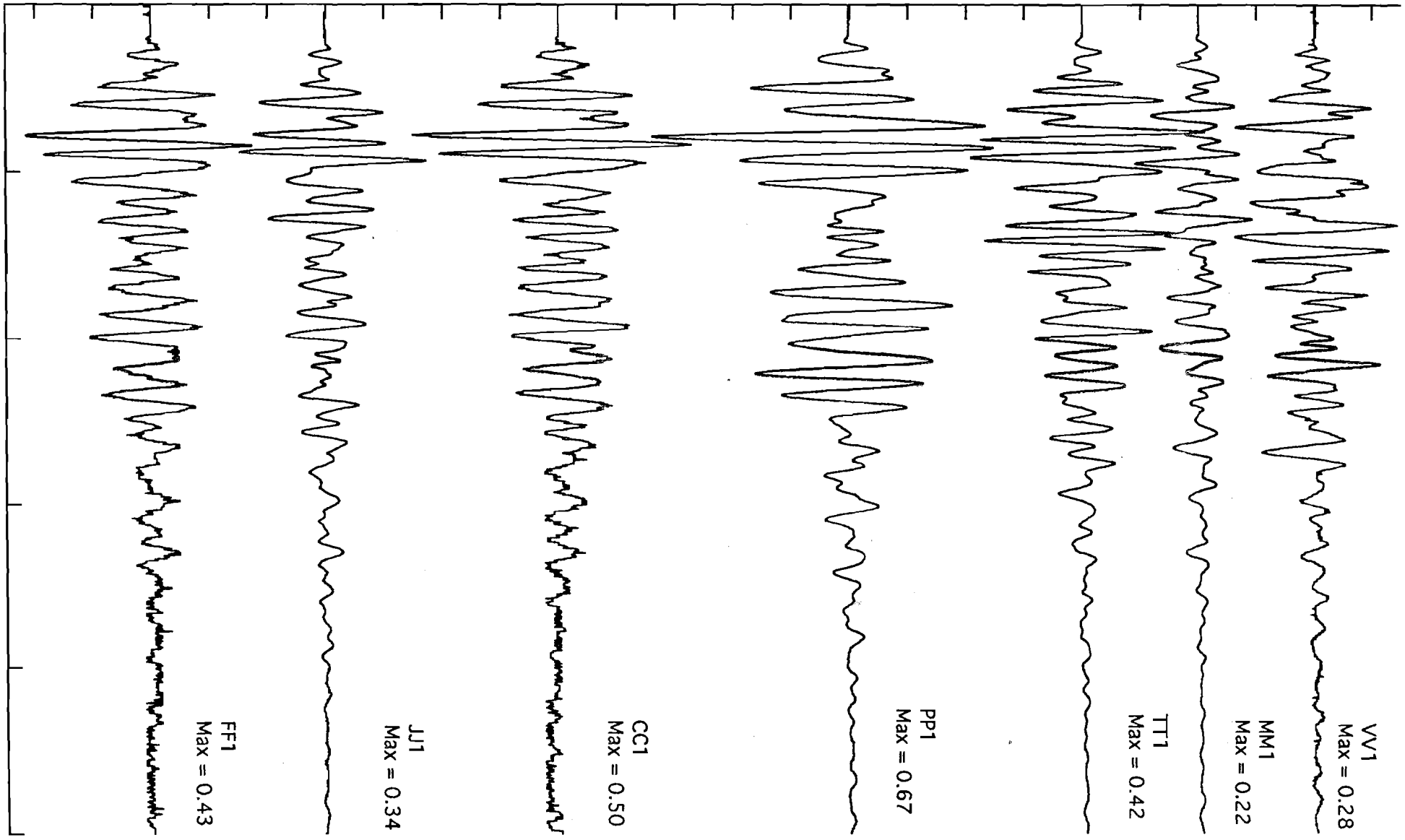

10:40 AM VERTICAL GROUND VIBRATION , in/sec
(All seismographs same model)
ID780
Max = 0.225
Depth = 3 in
ID189
Max = 0.215
Depth = 3 in
ID150
Max = 0.27
Depth = 6 in
ID461
Max = 0.245
Depth = 6 in
ID187
Max = 0.265
Depth = 6 in
.3
.2
.1
0
-.1
-.2
-.3
0.0
0.2
0.4
0.6
0.8
1.0
TIME, sec
DESA

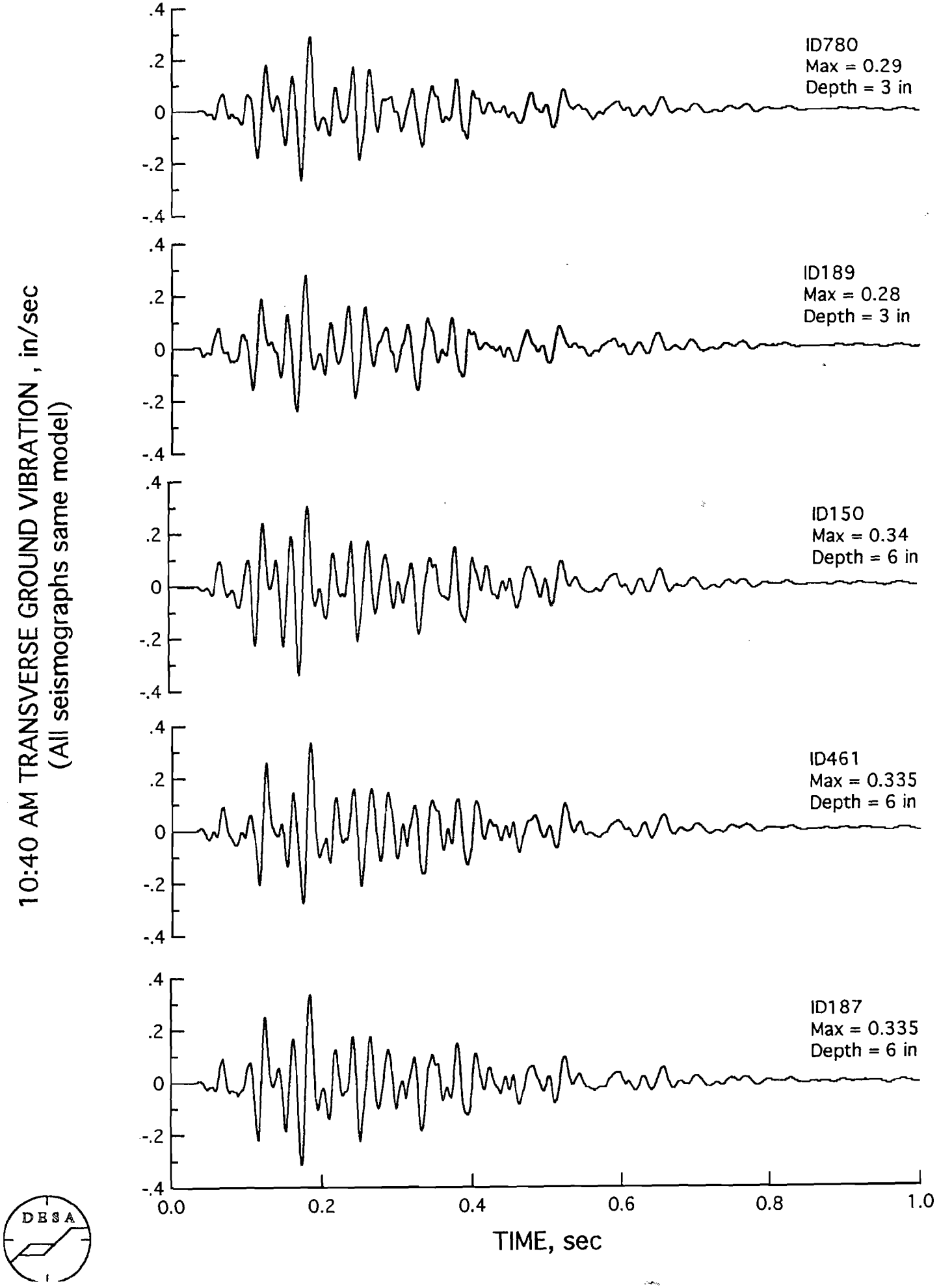

10:50 AM VERTICAL GROUND VIBRATION, in/sec
TICK MARKS: 0.02 in/sec
MM2
Max = 0.09
TT2
Max = 0.11
PP2
Max = 0.12
JJ2
Max = 0.11
CC2
Max = 0.16
FF2
Max = 0.13
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
TIME, sec
DESA

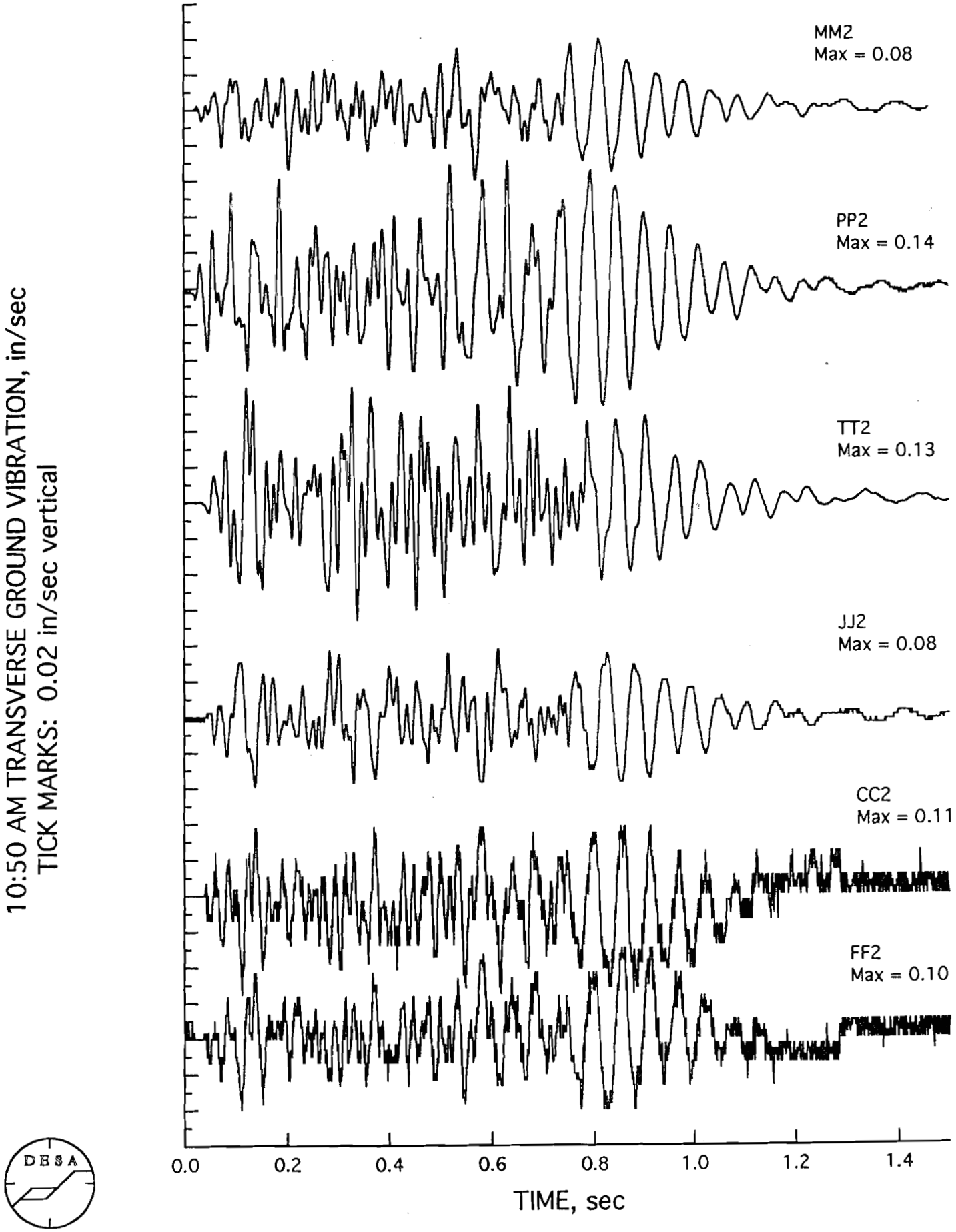

10:50 AM VERTICAL GROUND VIBRATION , in/sec
(All seismographs same model)
.12
.08
.04
0
-.04
-.08
-.12
ID780
Max = 0.085
Depth = 3 in
ID189
Max = 0.10
Depth = 3 in
ID150
Max = 0.105
Depth = 6 in
ID461
Max = 0.09
Depth = 6 in
ID187
Max = 0.16
Depth = 6 in
0.10
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
TIME, sec
DESA

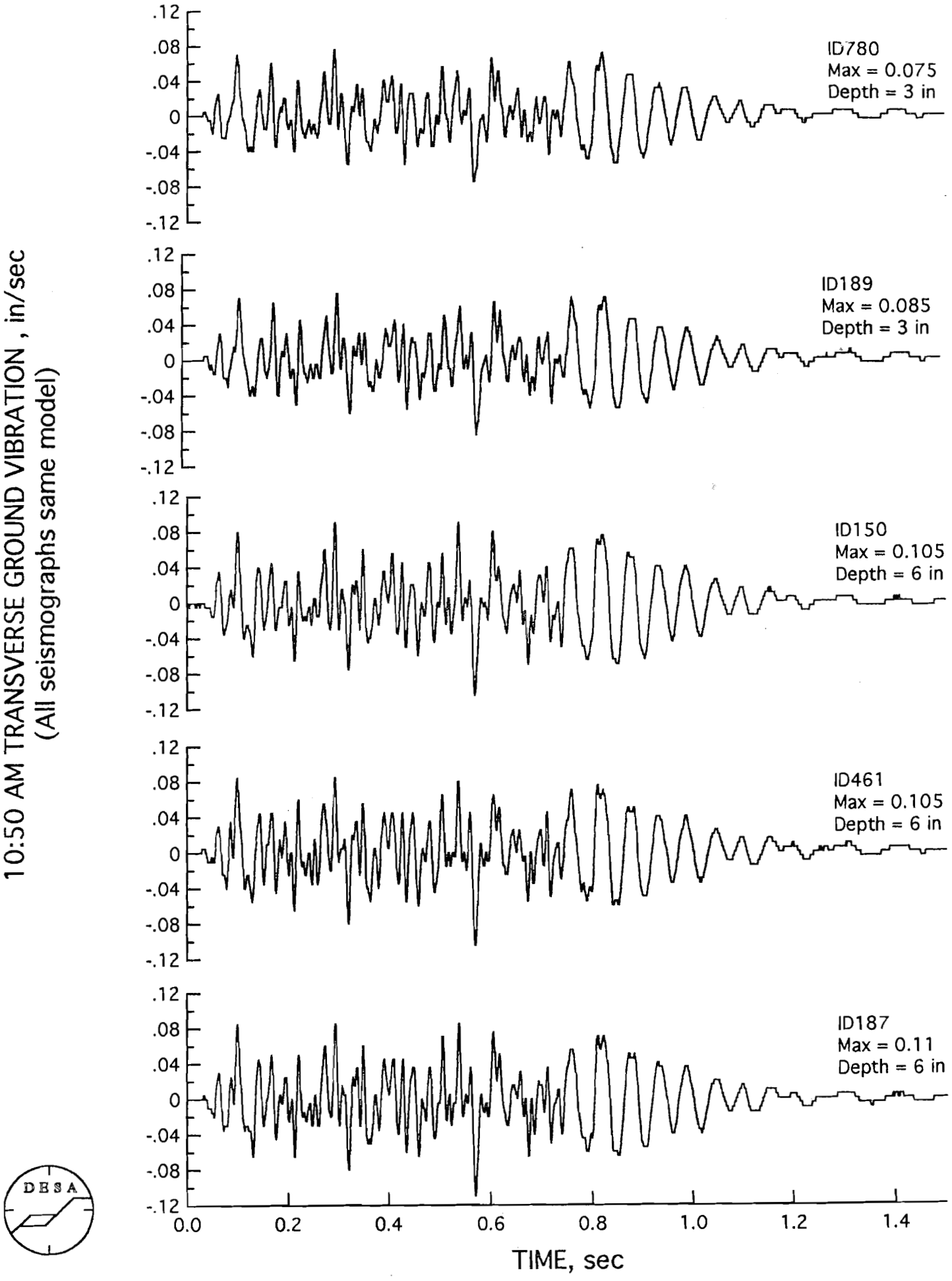
10:40 AM TRANSVERSE GROUND VIBRATION, in/sec

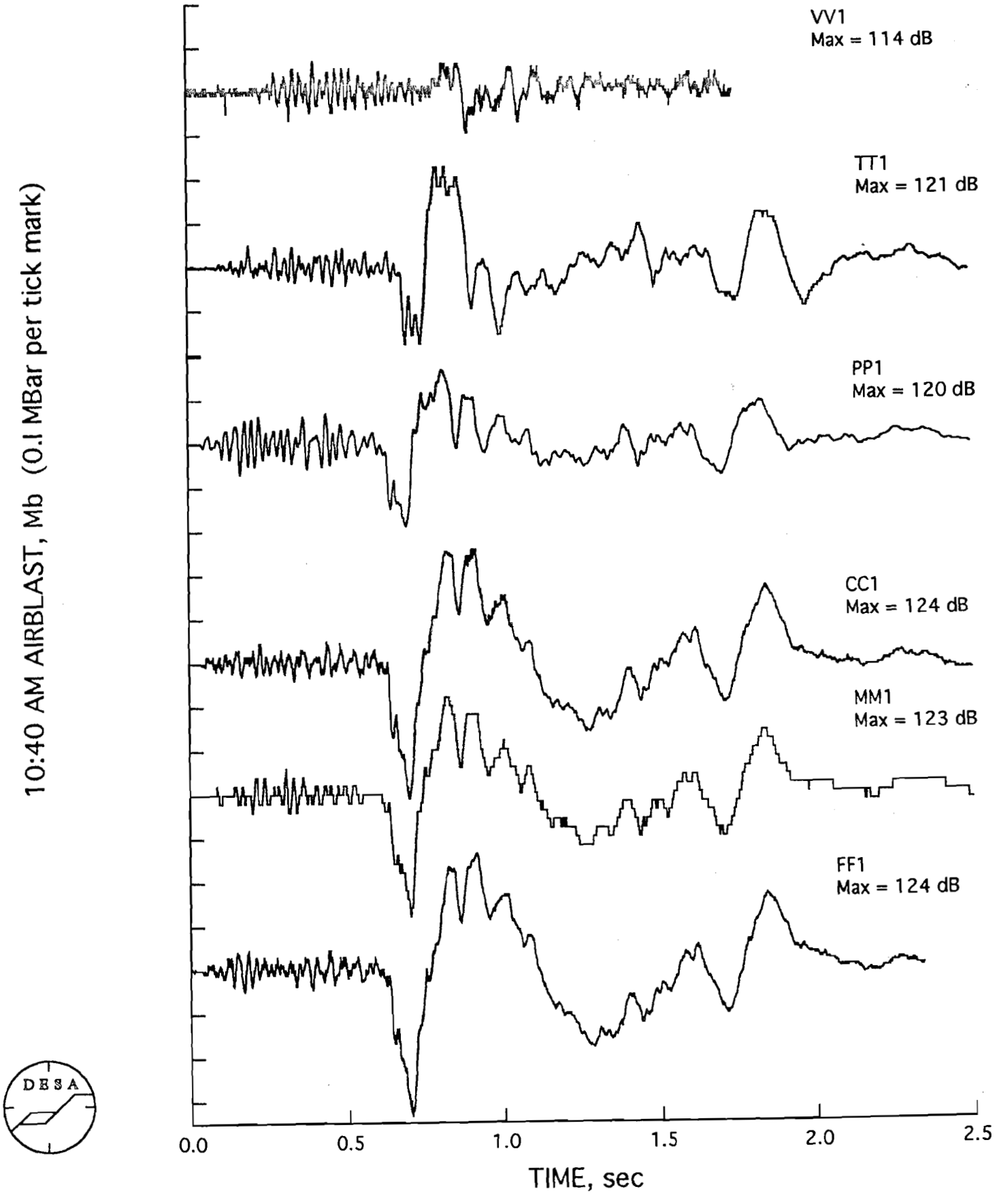
TICK MARKS: 0.2 in/sec per vertical and 0.2 sec per horizontal

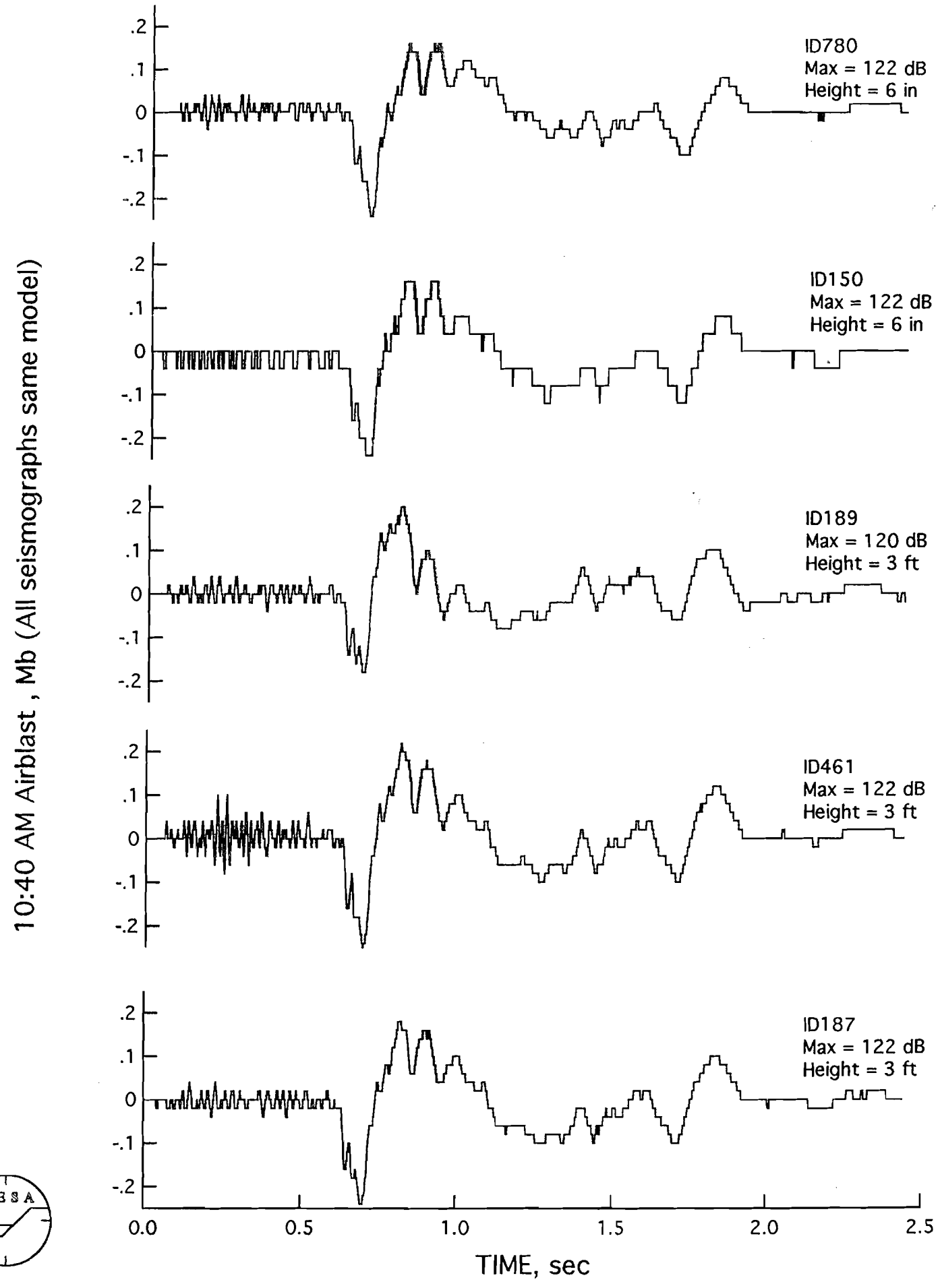


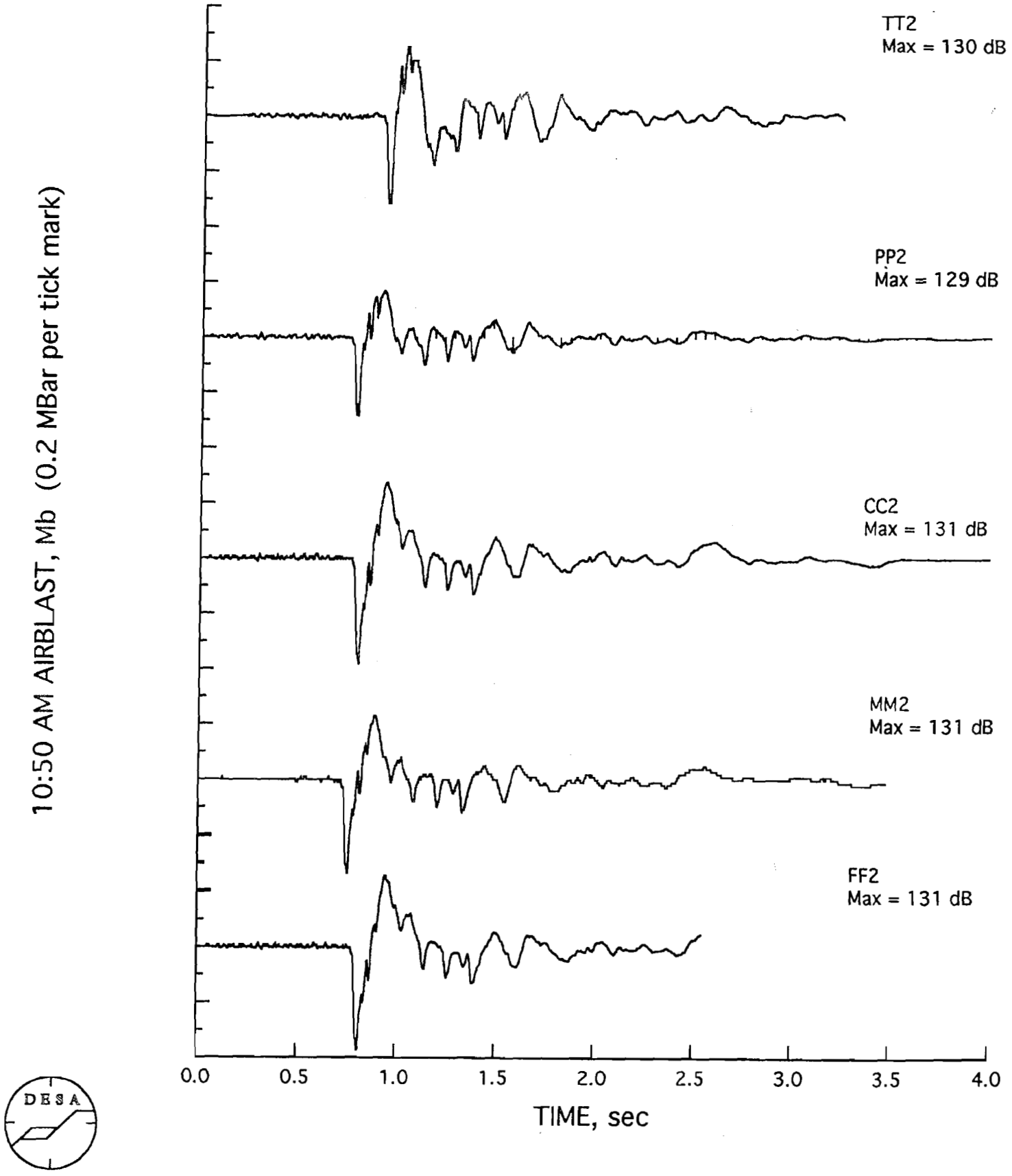

10:40 AM TRANSVERSE GROUND VIBRATION , in/sec
(All seismographs same model)
ID780
Max = 0.29
Depth = 3 in
ID189
Max = 0.28
Depth = 3 in
ID150
Max = 0.34
Depth = 6 in
ID461
Max = 0.335
Depth = 6 in
ID187
Max = 0.335
Depth = 6 in
.4
.2
0
-.2
-.4
0.0
0.2
0.4
0.6
0.8
1.0
TIME, sec
DESA

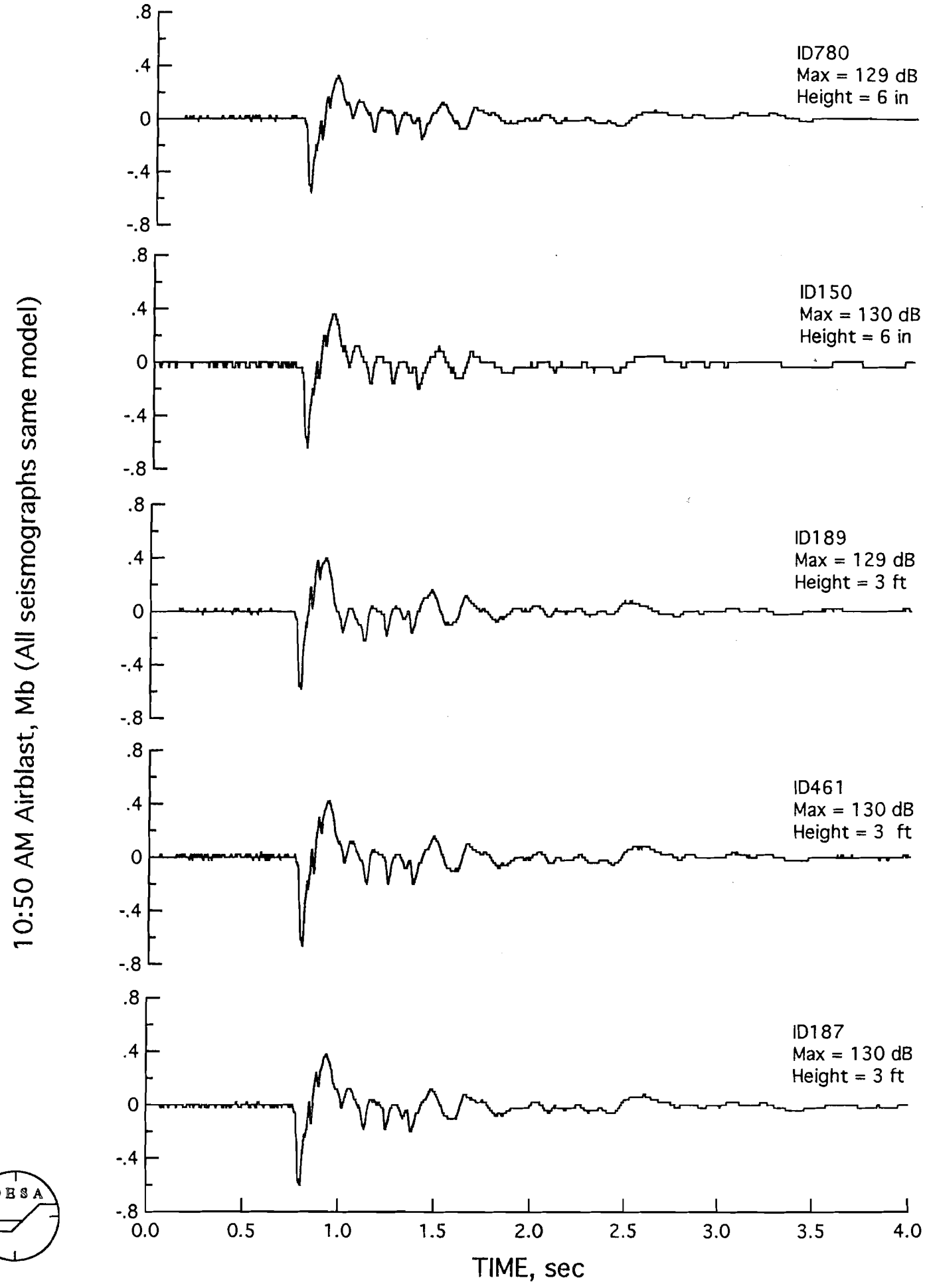

10:50 AM TRANSVERSE GROUND VIBRATION, in/sec
TICK MARKS: 0.02 in/sec vertical
MM2
Max = 0.08
PP2
Max = 0.14
TT2
Max = 0.13
JJ2
Max = 0.08
CC2
Max = 0.11
FF2
Max = 0.10
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
TIME, sec
DESA

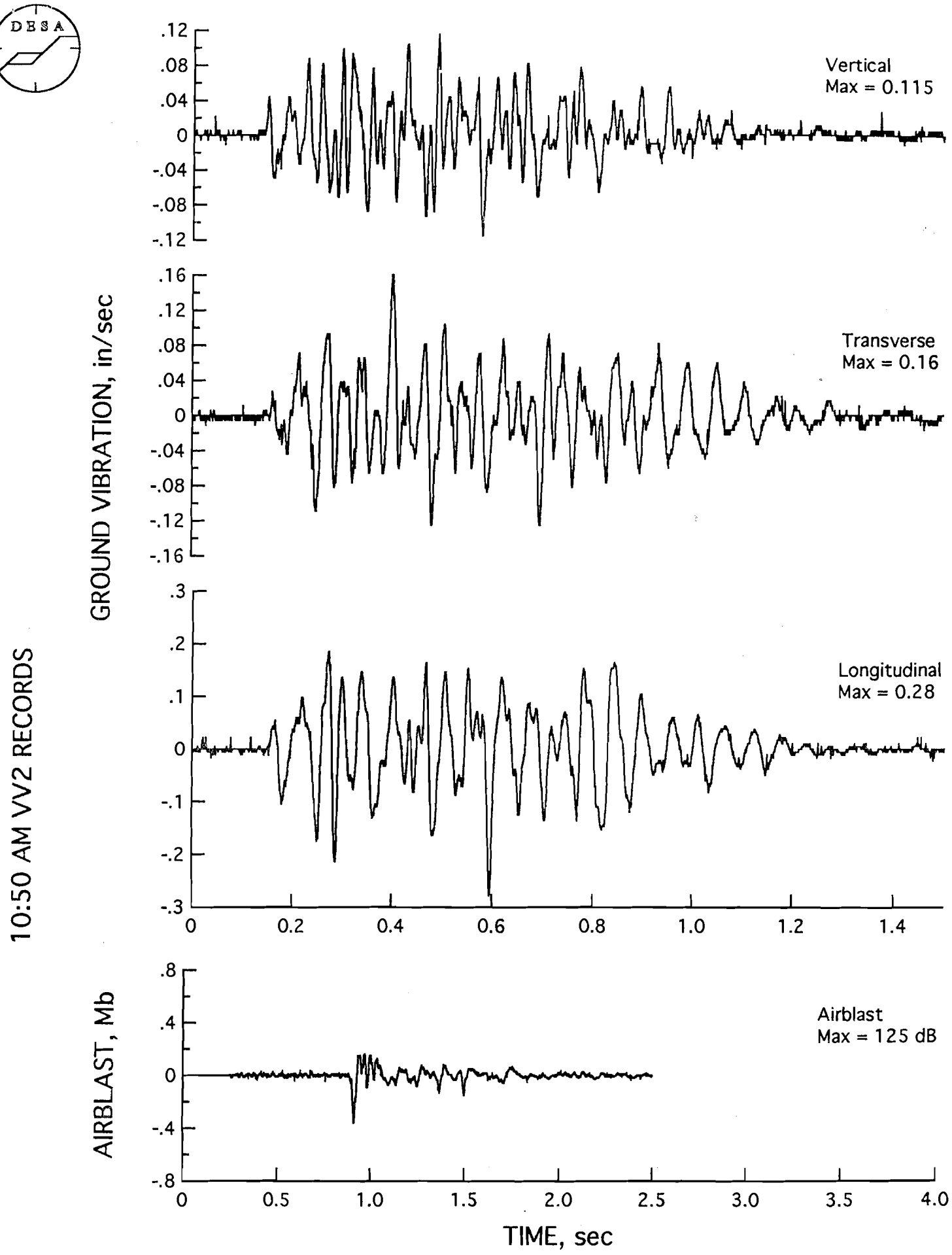

10:50 AM TRANSVERSE GROUND VIBRATION , in/sec
(All seismographs same model)
.12
.08
.04
0
-.04
-.08
-.12
ID780
Max = 0.075
Depth = 3 in
ID189
Max = 0.085
Depth = 3 in
ID150
Max = 0.105
Depth = 6 in
ID461
Max = 0.105
Depth = 6 in
ID187
Max = 0.11
Depth = 6 in
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
TIME, sec
DESA


10:40 AM AIRBLAST, Mb (0.1 MBar per tick mark)
VV1
Max = 114 dB
TT1
Max = 121 dB
PP1
Max = 120 dB
CC1
Max = 124 dB
MM1
Max = 123 dB
FF1
Max = 124 dB
0.0
0.5
1.0
1.5
2.0
2.5
TIME, sec
DESA

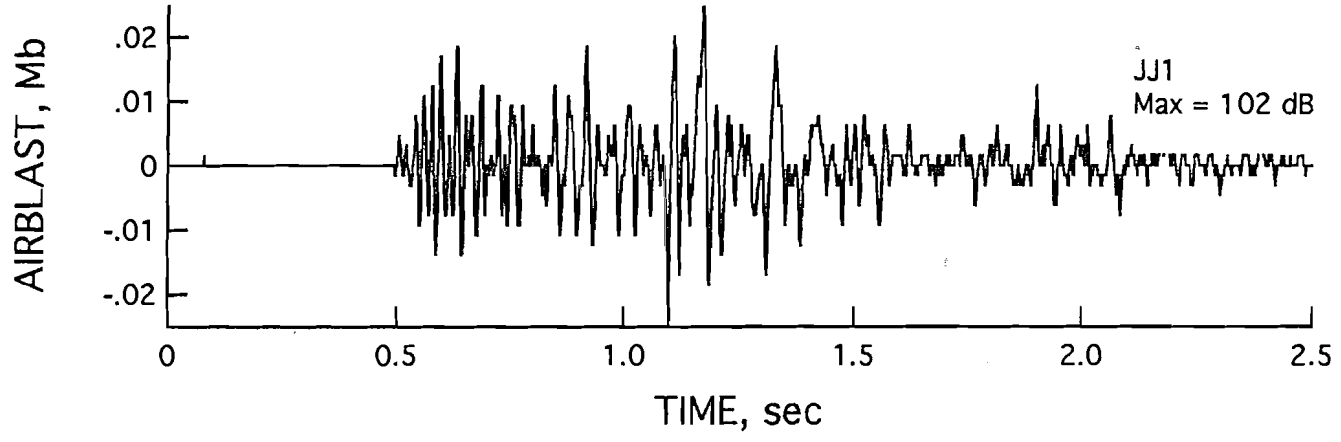

10:40 AM Airblast , Mb (All seismographs same model)
.2
.1
0
-.1
-.2
ID780
Max = 122 dB
Height = 6 in
ID150
Max = 122 dB
Height = 6 in
ID189
Max = 120 dB
Height = 3 ft
ID461
Max = 122 dB
Height = 3 ft
ID187
Max = 122 dB
Height = 3 ft
0.0
0.5
1.0
1.5
2.0
2.5
TIME, sec
DESA

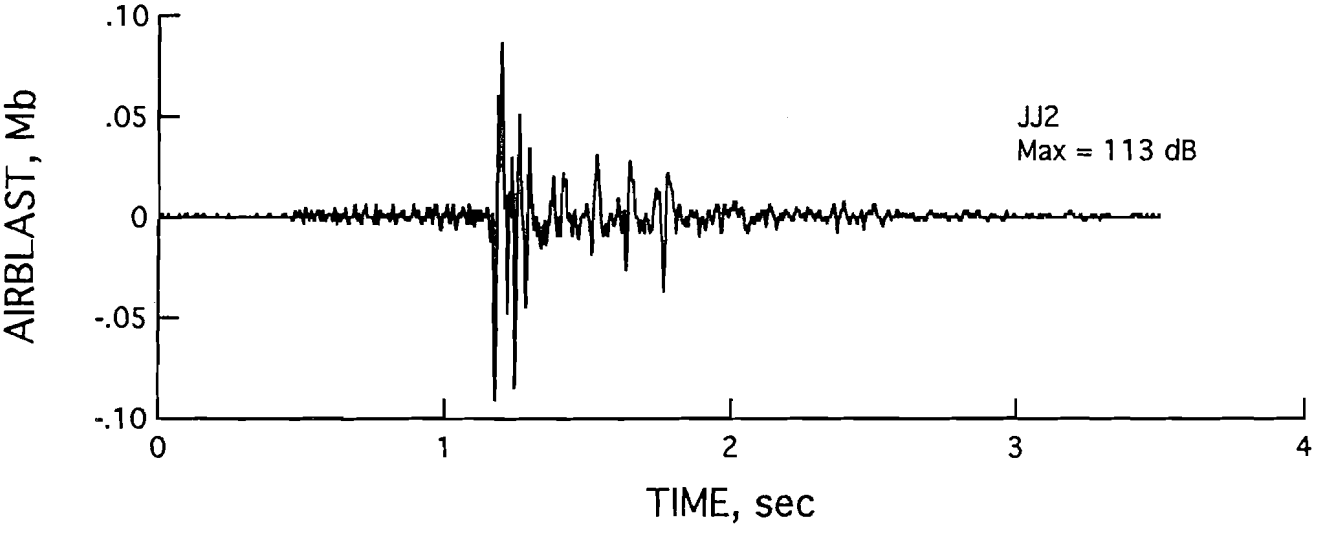

10:50 AM AIRBLAST, Mb (0.2 MBar per tick mark)
TT2
Max = 130 dB
PP2
Max = 129 dB
CC2
Max = 131 dB
MM2
Max = 131 dB
FF2
Max = 131 dB
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
TIME, sec
DESA


10:50 AM Airblast, Mb (All seismographs same model)
ID780
Max = 129 dB
Height = 6 in
ID150
Max = 130 dB
Height = 6 in
ID189
Max = 129 dB
Height = 3 ft
ID461
Max = 130 dB
Height = 3 ft
ID187
Max = 130 dB
Height = 3 ft
.8
.4
0
-.4
-.8
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
TIME, sec
DESA


DESA
10:50 AM VV2 RECORDS
GROUND VIBRATION, in/sec
.12
.08
.04
0
-.04
-.08
-.12
Vertical
Max = 0.115
.16
.12
.08
.04
0
-.04
-.08
-.12
-.16
Transverse
Max = 0.16
.3
.2
.1
0
-.1
-.2
-.3
Longitudinal
Max = 0.28
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
AIRBLAST, Mb
.8
.4
0
-.4
-.8
Airblast
Max = 125 dB
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
TIME, sec

10:40 and10:50 AM JJ AIRBLAST RECORDS





DESA