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JEFFERSON

Containment Data Report

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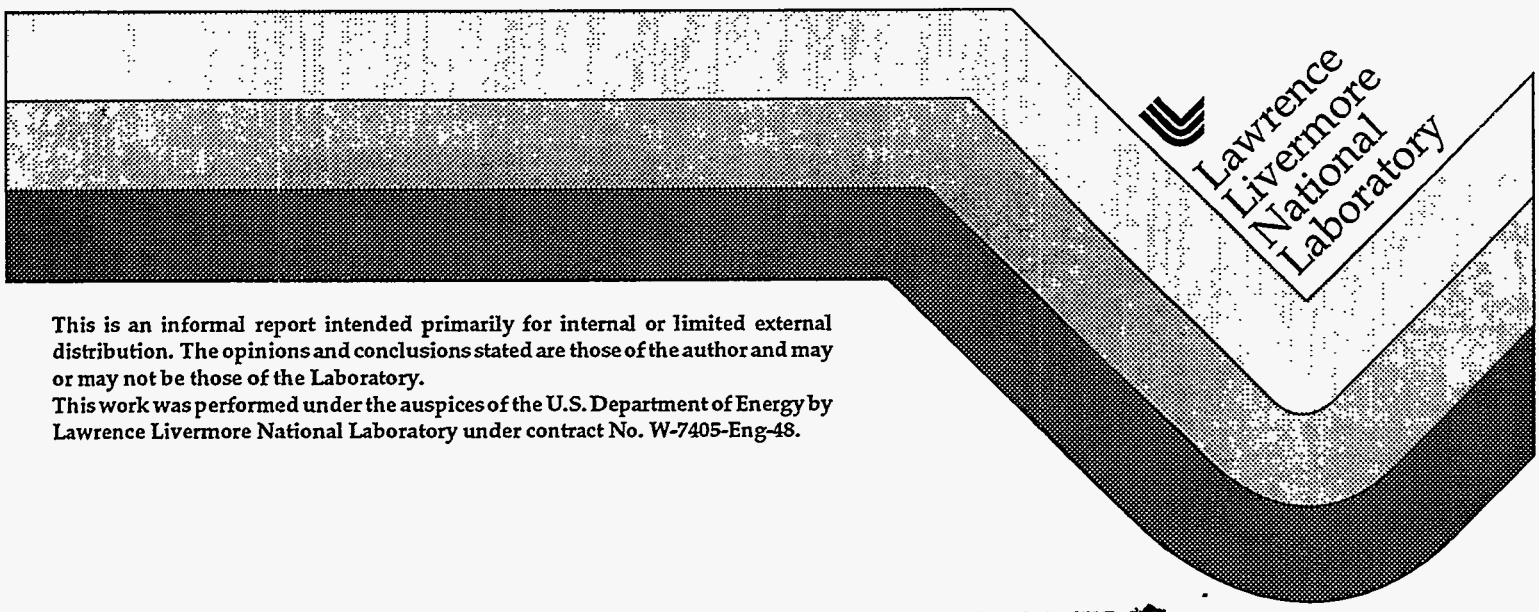
December 1994



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Classification Guide	Topic Number	Subject
COK-88-024	1.5.6	Event announcement
NV-89-18		Event announcement
TCG-WT-1	1113	Contractor identification
TCG-WT-1	1121	Personnel identification
TCG-WT-1	1210	Geology
TVG-WT-1	1260	Crater (map)
TCG-WT-1	1413	Statement concerning venting
TCG-WT-1	1452	Event announcement
TCG-WT-1	1831	Depth of burial
TCG-WT-1	1843	Stemming material, amount,etc
TCG-WT-1	1925	Diagnostic canister dimensions
TCG-WT-1	3542.3	Ground motion
TCG-WT-1	4810	Radiation measurement
TCG-WT-1	4820	Acceleration, pressure, temperature measurement

JEFFERSON Instrumentation Summary

Instrumentation	Fielded	Data Return	Present in this Report
Plug Emplacement	yes	yes	yes
Radiation	yes	yes	yes
Pressure			
Stemming	yes	yes	yes
Challenge	no	-	-
Cavity	no	-	-
Atmospheric	no	-	-
Motion			
Free field	no	-	-
Surface	yes	yes	yes
Plug	no	-	-
Stemming	yes	yes	yes
Surface casing	no	-	-
Emplacement pipe	no	-	-
Recording trailer	yes	yes	yes
Hydroyield (a)	yes	yes	no
Collapse (b)	yes	yes	yes
Stress (c)	yes	yes	yes
Strain (d)	yes	yes	yes
Other Measurements	yes	yes	yes

(a) CORRTEX in emplacement hole.
(b) EXCOR and CLIPER in emplacement hole.
(c) In bottom plug.
(d) In top plug.

Event Personnel

Containment Physics	
B. Hudson	LLNL
J. Kalinowski	EG&G/AVO
T. Stubbs	EG&G/AVO

Instrumentation	
C. Cordill	LLNL
R. Salazar	EG&G/AVO
R. Spilsbury	EG&G/NVO
A. Moeller	EG&G/NVO

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1. Event Description

1.1 Containment summary

The JEFFERSON event was detonated in hole U20ai of the Nevada Test Site (see figure 1.1). Detonation time was 06:30 PDT on April 22, 1986. A subsurface collapse extending upward to a depth of about 190 m (just above plug four, the stemming platform) occurred about 2 hours 38 minutes after detonation. No radiation arrivals were detected above ground and the JEFFERSON event containment was considered satisfactory.

1.2 Site

A magnified geologic map showing some of the surface features near the U20ai site is shown in Figure 1.2. The device had a burial depth of 608 m in Area 4 tuffs, about 20 m above the static water level (SWL), as shown in the geologic cross sections (figure 1.3[1]).

Stemming of the 2.44 m diameter emplacement hole followed the plan shown in figure 1.4. A log of the stemming operations was maintained by Holmes & Narver[2].

1.3 Instrumentation

Figure 1.5 gives a schematic layout of the instrumentation in hole U20ai, designed to monitor the stemming emplacement procedures and performance on the JEFFERSON event.

Each of the five sanded gypsum concrete (SGC) plugs was monitored during emplacement with arrays of thermistors and conductivity probes to determine its position, thickness and curing history. Pressure and radiation were monitored in the coarse stemming on either side of the central three SGC plugs. All data signals from these stations were transmitted in analog form to the recording trailer where they were recorded on magnetic tape.

Sensitive pressure transducers were fielded below plugs 4 & 5 and in the ground surface as part of an investigation of the permeability of the upper layers of the Nevada Test Site. Signals from these stations were digitized through a Waveteck® system and recorded on disk by a LSI 11/23 computer.

Hydrodynamic yield of the device and cavity collapse and chimney formation were monitored by two CLIPER/CORRTEX cables and one EXCOR/CORRTEX cable. Results of the hydrodynamic yield measurements are reported elsewhere[3].

Bi-axial stress and strain transducers[4] were fielded in the bottom plug as part of a continuing transducer development program to measure stress near the 1.0 Kbar level.

Vertical motion was monitored in each of the five SGC plugs, in the stemming between the plugs, on the surface casing and in the ground surface, 15.24 m from surface ground zero (SGZ). Triaxial motion of the recording trailer was also recorded. Relative displacement between the surface casing and the top plug was monitored by an array of seven proximity switches mounted in the plug next to the bottom of the surface casing.

A brief history of the fielding operations of the instrumentation, including emplacement pipe strain measurements, is given in reference 5. Further details of the instrumentation are given in reference 6.

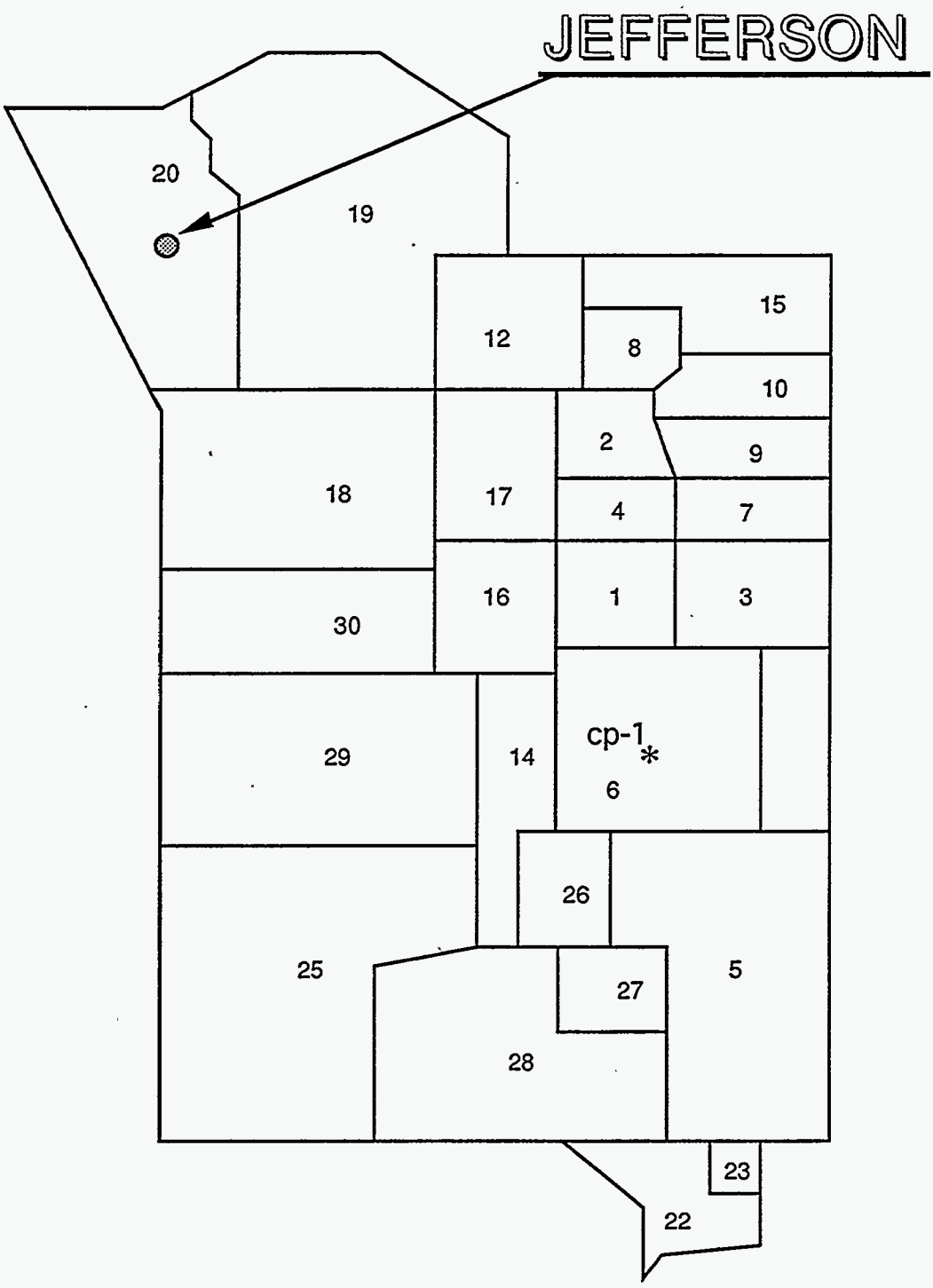
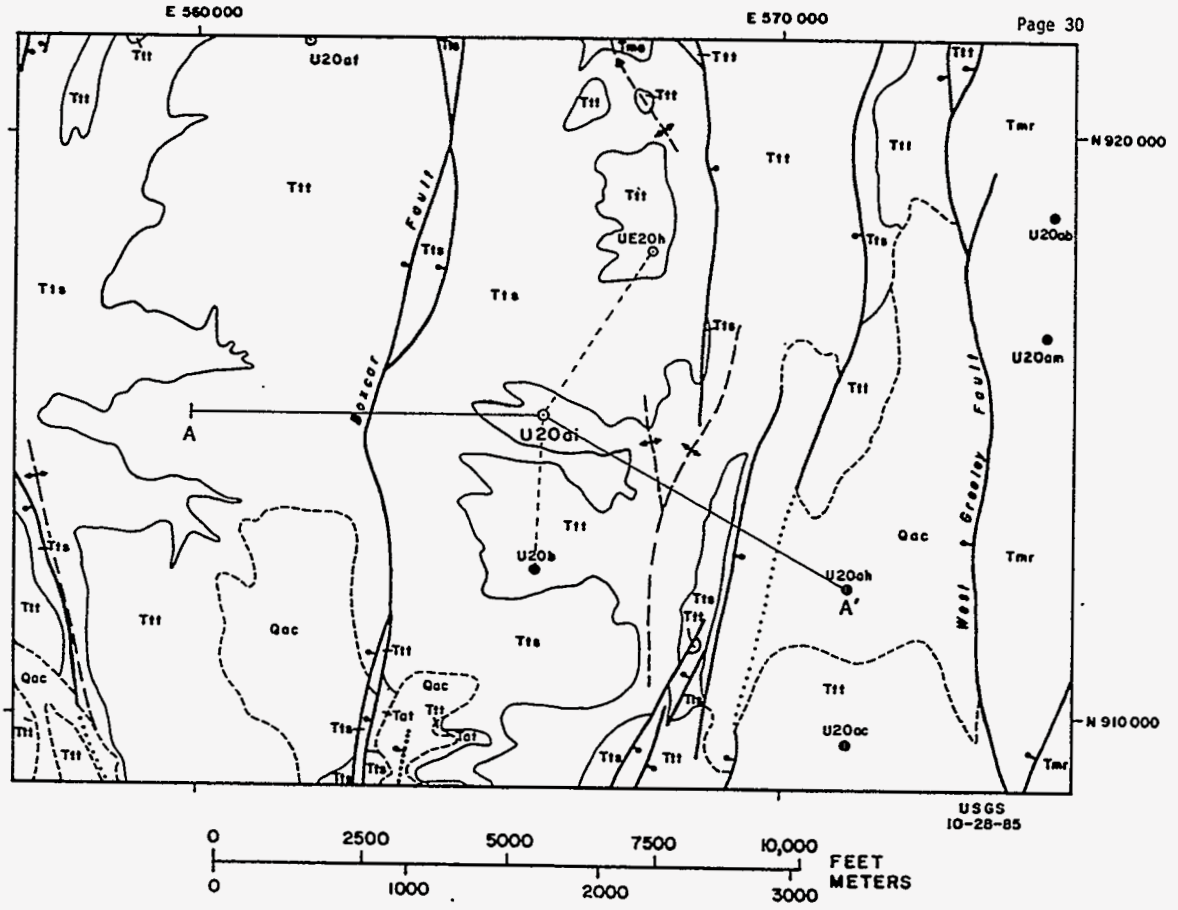
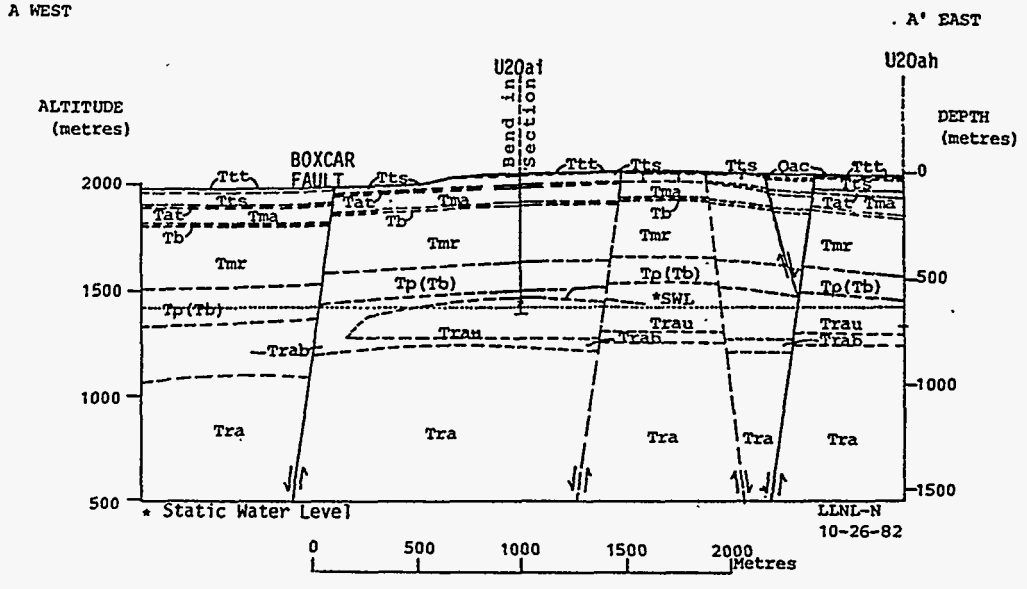


Figure 1.1 Map of the Nevada Test Site indicating the location of hole U20ai.



GEOLOGY MAP OF U20ai

Figure 1.2 Geologic Map of the region near hole U20ai.



GEOLOGIC CROSS SECTION THROUGH U20ai

Identification of units used in the geologic map and cross section, U20ai

	Quaternary units
Qac	Alluvium and colluvium
	Tertiary units
Ttt	Trail Ridge Member, Thirsty Canyon Tuff
Tts	Spearhead and Rocket Wash (?) Members, Thirsty Canyon Tuff
Tat	Ash-fall and reworked tuff
Tma	Ammonia Tanks Member, Timber Mountain Tuff
Tb	Vitric Bedded Tuff
Tmr	Rainier Mesa Member, Timber Mountain Tuff
Tp(Tb)	Bedded tuff associated with the Paintbrush Tuff
Trab	Bedded and ash-flow tuffs, tuffs and rhyolites of Area 20
Trau	Upper rhyolite lavas, tuffs and rhyolites of Area 20
Tra	Tuffs and rhyolites of Area 20, undifferentiated

Figure 1.3 Geologic cross section through hole U20ai.

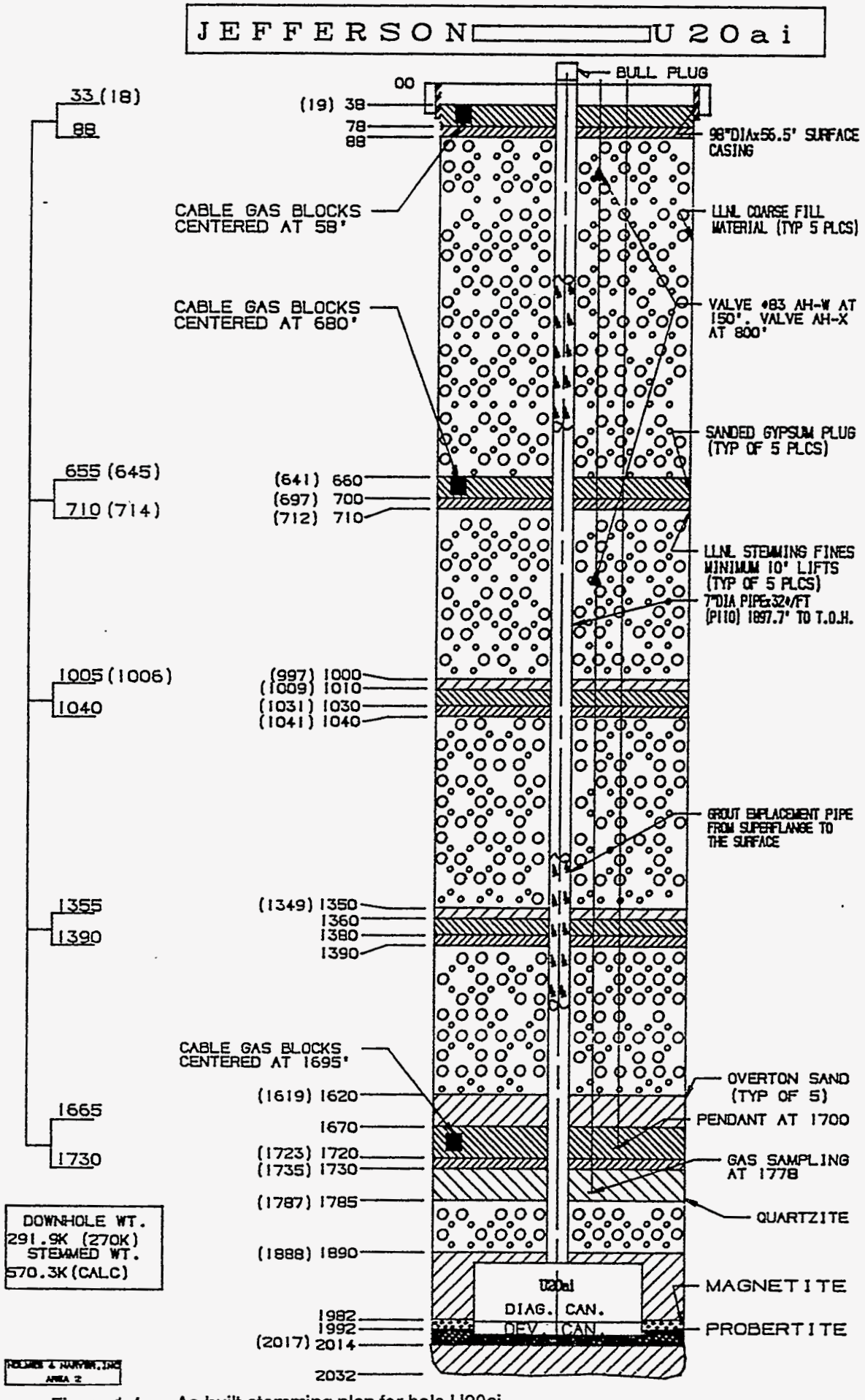
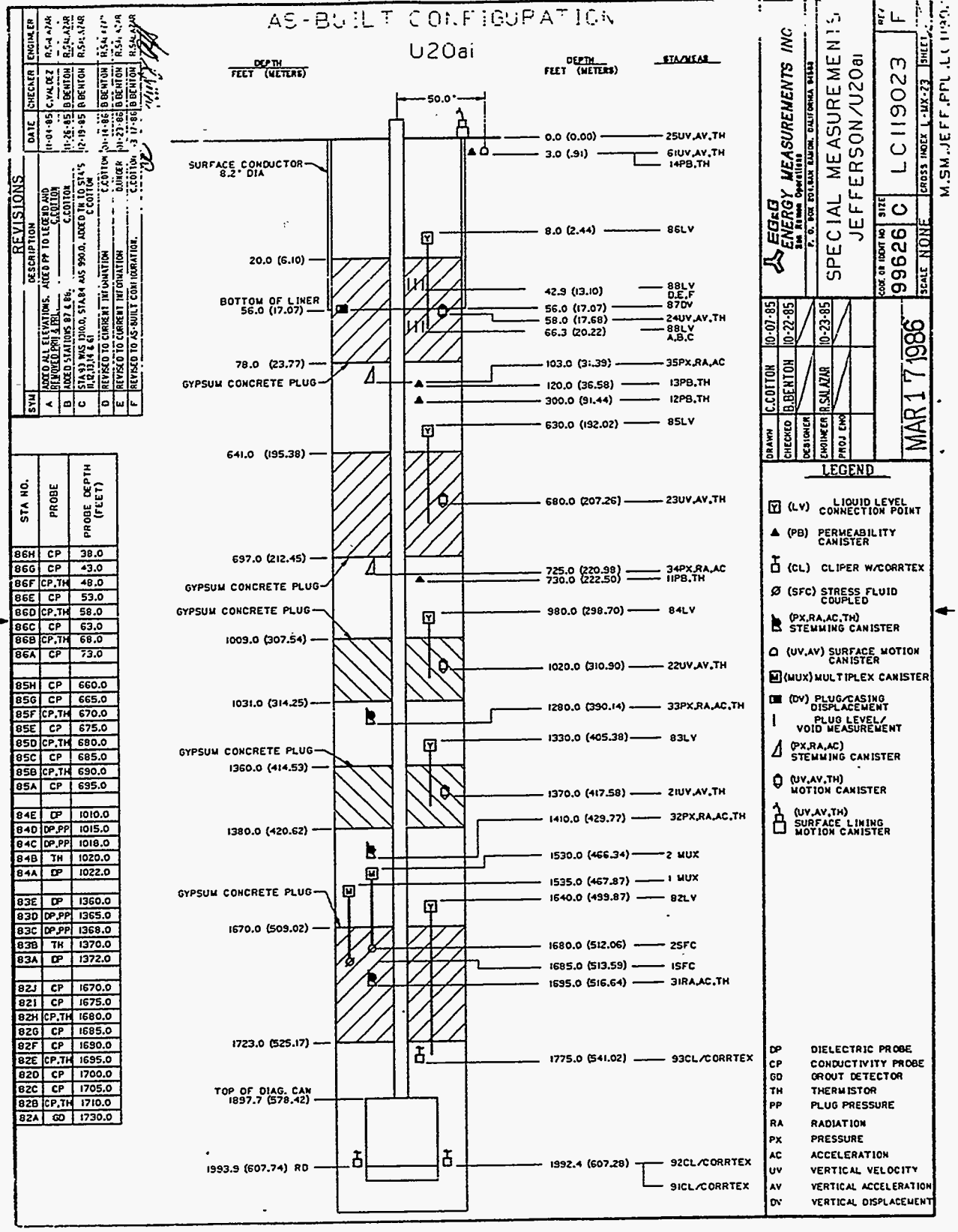


Figure 1.4 As-built stemming plan for hole U20ai.



STA NO.	PROBE	PROBE DEPTH (FEET)
86H	CP	38.0
86G	CP	43.0
86F	CP,TH	48.0
86E	CP	53.0
86D	CP,TH	58.0
86C	CP	63.0
86B	CP,TH	68.0
86A	CP	73.0
85H	CP	660.0
85G	CP	665.0
85F	CP,TH	670.0
85E	CP	675.0
85D	CP,TH	680.0
85C	CP	685.0
85B	CP,TH	690.0
85A	CP	695.0
84E	DP	1010.0
84D	DP,PP	1015.0
84C	DP,PP	1018.0
84B	TH	1020.0
84A	DP	1022.0
83E	DP	1360.0
83D	DP,PP	1365.0
83C	DP,PP	1368.0
83B	TH	1370.0
83A	DP	1372.0
82J	CP	1670.0
82I	CP	1675.0
82H	CP,TH	1680.0
82G	CP	1685.0
82F	CP	1690.0
82E	CP,TH	1695.0
82D	CP	1700.0
82C	CP	1705.0
82B	CP,TH	1710.0
82A	GD	1730.0

Figure 1.5 As-built containment instrumentation plan for the JEFFERSON event emplacement hole U20ai.

2. Emplacement

2.1 Instrumentation

During installation, some of the mounting brackets were broken on the motion canisters intended to be placed in plugs one, three and four. This allowed the orientation of the canisters to be slightly off vertical.

2.2 Pipe strain

Strain on the emplacement pipe was not recorded on JEFFERSON.

2.3 Plug levels and temperature

The emplacement of each of the five SGC plugs was monitored with an array of conductivity probes and thermistors. The locations of the probes are tabulated in figure 1.5. Figures 2.1-2.5 show plots of the SGC emplacement and temperature histories. Open circles indicate the upper and lower boundary positions of the plugs as measured using tag lines while solid circles indicate the positions of the probe stations and the times at which the conductivity probes were activated. Most of the temperature sensors accompanied conductivity probes as indicated in figure 1.5 and the captions of figures 2.1–2.5. The temperature probes in the second and third plugs were fielded midway between conductivity sensors.

All plugs were emplaced as planned.

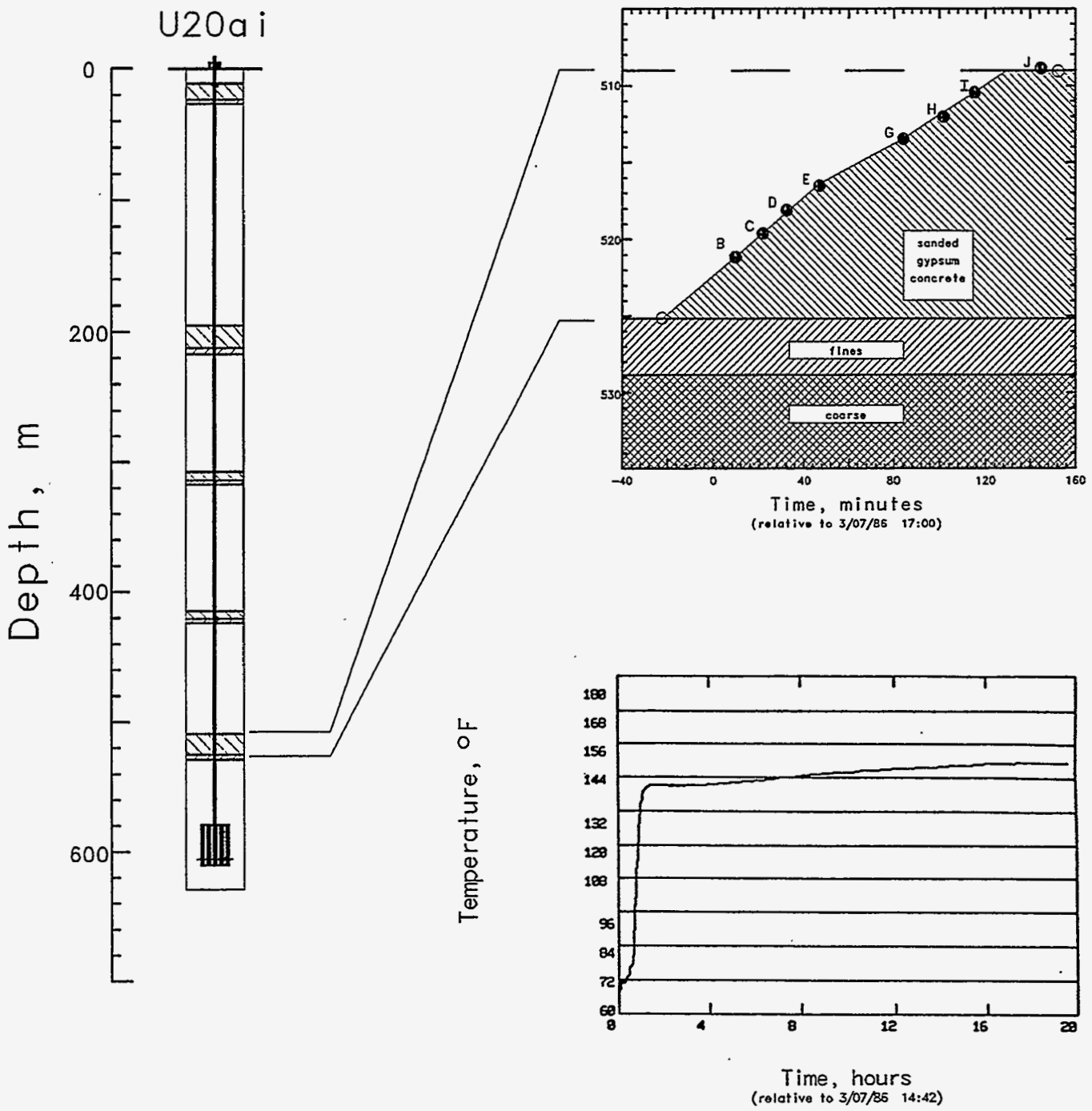


Figure 2.1 Sanded gypsum emplacement for the first plug. The upper and lower plug boundaries were determined with a tag line (open circles). Solid symbols indicate the probe elevations. Probes labeled B, E, and H included temperature sensors. The temperature history of probe B is shown as representative of the first 20 hours.

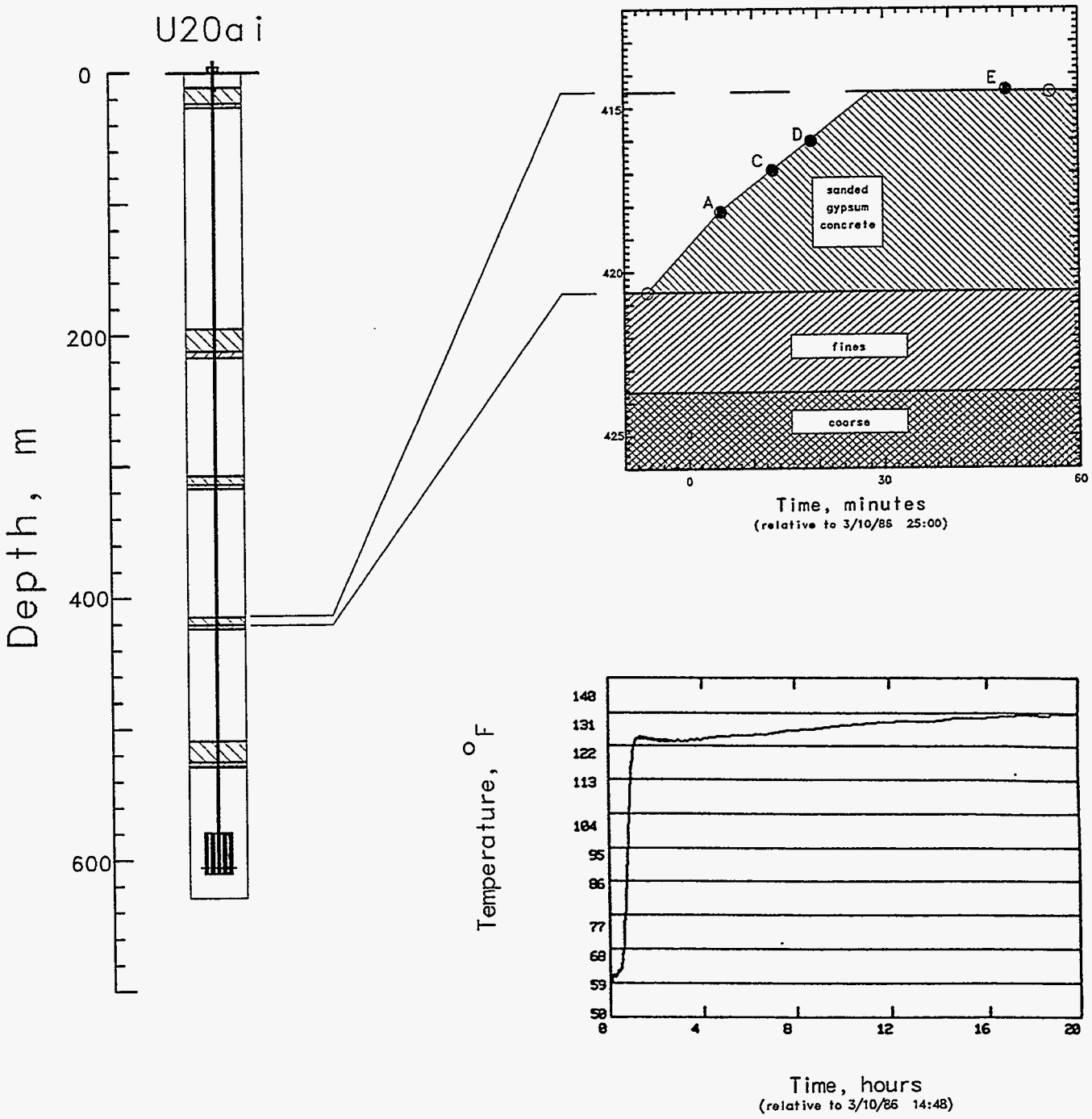


Figure 2.2 Sanded gypsum emplacement for the second plug . The upper and lower plug boundaries were determined with a tag line (open circles). Solid symbols indicate the probe elevations. Probe labeled B included only a temperature sensor and is not shown in the grout level plot. It was located midway between probes A and C.

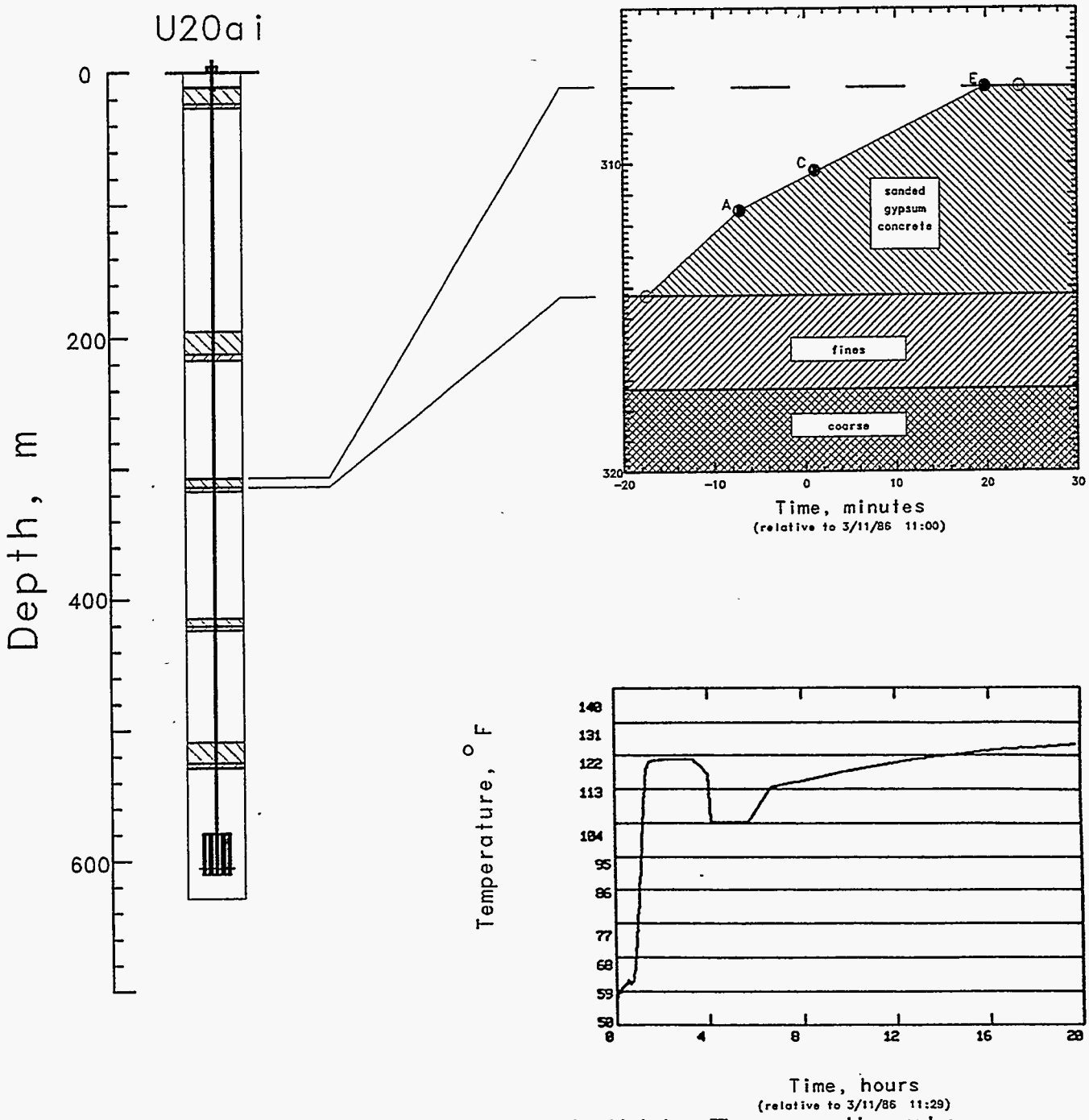


Figure 2.3 Sanded gypsum emplacement for the third plug. The upper and lower plug boundaries were determined with a tag line (open circles). Solid symbols indicate the probe elevations. Probe labeled B included a only temperature sensor and is not shown in the grout level plot. It was located midway between probes A and C. The dip in temperature near the four-hour point of the record is due to grouting of the emplacement pipe.

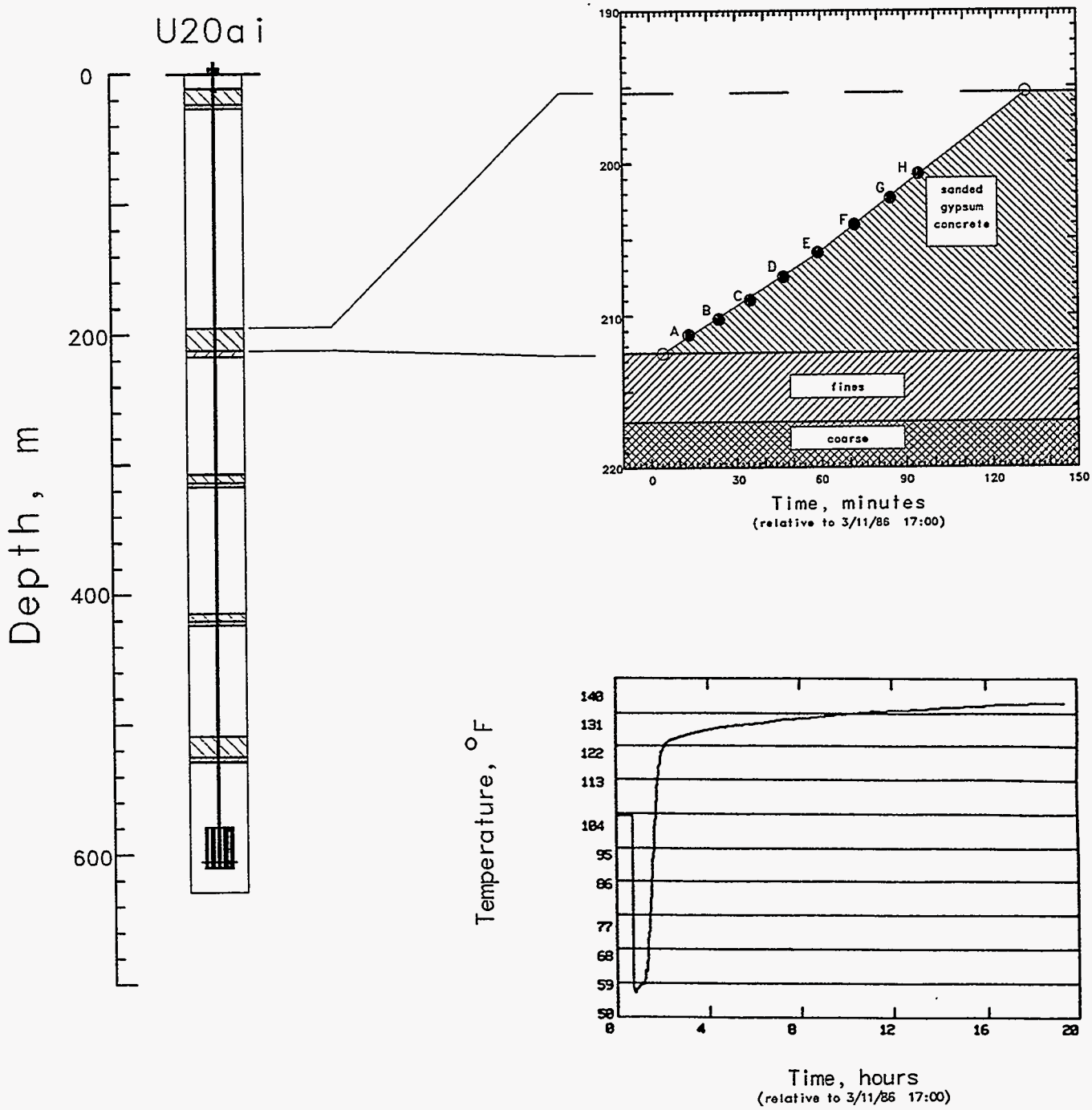


Figure 2.4 Sanded gypsum emplacement for the fourth plug. The upper and lower plug boundaries were determined with a tag line (open circles). Solid symbols indicate the probe elevations. Probes labeled B, D, and F included temperature sensors. The temperature history of probe F is shown as representative of the first 20 hours. The initial temperature level (about 104 degrees F) is unexplained.

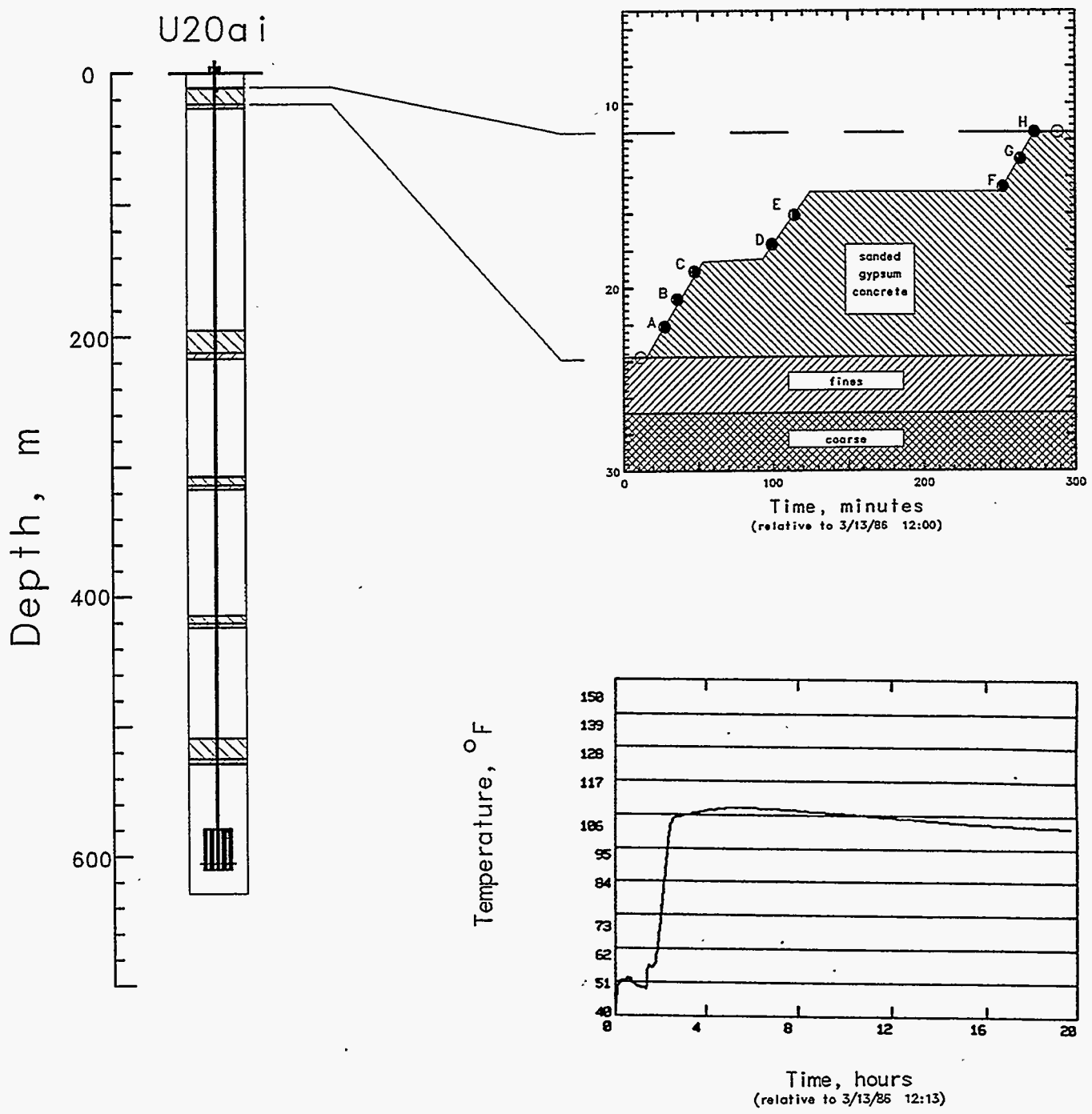


Figure 2.5 Sanded gypsum emplacement for the fifth plug . The upper and lower plug boundaries were determined with a tag line (open circles). Solid symbols indicate the probe elevations. Probes labeled B, D, and F included temperature sensors. The temperature history of probe D is shown as representative of the first 20 hours.

3. Stemming Performance

All signals from stations at depths greater than 31 m in the emplacement hole were lost at about 2 s after detonation. This loss was most likely due to cable breakage caused by the excessive motion associated with the explosion. All recording was terminated 32 hours after the detonation.

3.1 Radiation and Pressure

As indicated in Figure 1.4, pressure and radiation were monitored in the region below each of the upper four SGC plugs.

Pressure and radiation histories, from a few seconds before detonation until recording termination or station failure, are displayed in Figures 3.1–3.5. The radiation signal from station 31 (in the bottom plug) went beyond band edge prior to 2 s while stations at shallower depths show little, if any, indication of radiation arrivals. At station 32 (below the second SGC plug) a large pressure pulse arrives at about 0.1 s and peaks at about 0.5 s with a pressure change of around 22 psi. Stations at shallower depths show a different behavior, suggesting that the early time pressure history of the stemming column may be that of compaction and dilatation due to the passage of the shock wave.

All pressure and radiation data are consistent with satisfactory containment.

3.2 Motion

Recording on magnetic tapes containing the data from all stations in the SGC plugs (except station 31), the ground surface and on the surface casing was halted at about 2 s by the strong explosion–induced motion of the recording trailer. Stations 24 (in the top plug), 25 (on the surface casing), and 35 (in the stemming below the top plug) were the only stations in the emplacement hole to survive beyond 2.5 seconds. Although station 24 and 25 survived, the tapes recording the signals were halted at that time precluding further explosion–induced motion from these stations. Subsequently, the tapes were restarted manually when the field crew re–entered the trailer.

Figures 3.6–3.16 show the explosion-induced vertical acceleration measured in the coarse stemming and in the stemming plugs. Station 25 monitored the vertical acceleration and velocity of the surface casing while station 61 monitored the vertical motion of the ground surface at a depth of 0.91 m and a horizontal range of 15.24 m from SGZ. Characteristics of the motion and motion transducers are given in tables 3.1–3.3.

3.3 Collapse

All three of the EXCOR cables were active post–shot. The time variation of the position of the deepest end of the cables as a function of time is shown in Figure 3.17. Subsurface collapse appears to have progressed upwards to a depth of about 190 m (close to the top of the fourth plug). A slight increase in pressure (about 0.1 psi) was registered at station 35 at about 9485 s and is plotted in figure 3.17 as a circle. The acceleration history of station 35 is superimposed (without amplitude scale) on figure 3.17 at the approximate elevation of that station. The acceleration seen corresponds to the collapse history reported by the EXCOR and suggests that the pressure change is the result of a slight stemming shift and that the stemming remains otherwise in place below the top plug.

The motion sensed at stations 24, 35, and 61 during the collapse phase (about 2 hours and 38 minutes) was of too low a magnitude to be meaningfully integrated, so only the measured signals are shown. The proximity switch array (station 87) registered no change of relative position of the top plug and surface casing at any time and the data from this station are not shown.

Table 3.1 Summary of Motion

Gauge	Slant Range (m)	Arrival Time (ms)	Peak Acceleration (g)	Peak Velocity (m/s)	Peak Displacement (m)	Residual Displacement (cm)
21av	190	74	22.4, 48.0	21.2	5.3	(a)
21uv		-	-	20.7	4.3	(a)
22av	297	115	8.0, 3.6	5.8	2.1	(a)
22uv		-	-	5.7	2.0	(a)
23av	401	160	2.2, 1.0	3.6	1.02	(a)
23uv		(b)	-	-	-	-
24av	590	139(c), 288	3.54, 8.3(d)	5.1	2.65	(a)
24uv		-	-	4.9	2.45	(a)
25av	608	143(c), 296	4.1, 8(d)	5.7	2.60	(a)
25uv		-	-	4.7	2.31	(a)
31av	91	31(c), 41(e)	(a)	-	-	-
32av	142	41(c), 75	53	23.5	14.3(f)	(a)
33av	218	52(c), 83	8	7.8	3.4	
34av	387	93(c), 156	4.4	5.0	2.3	
35uv	577	139(c), 230	5.1(g), 24(d)	5.1	2.56	-34
61av	608	310	5.0, 9.8(d)	5.0	2.58	(a)
61uv		-	-	5.0	2.50	(a)

(a) Signal lost before this value could be attained.
(b) Channel lost before this datum was attained.
(c) Emplacement pipe– or strongback–stemming interaction.
(d) Slap-down peak.
(e) Signal was lost at ground motion arrival.
(f) Peak of displacement not reached.

Table 3.2 Accelerometer Characteristics

Gauge	Natural Frequency (Hz)	Damping Ratio	System Range (g's)
21av	1020	0.65	600
22av	880	0.65	200
23av	300	0.85	50
24av	275	0.80	20
25av	290	0.75	20
31av(a)	30,000	0.002	5000
32av(a)	NA	NA	500
33av(a)	NA	NA	250
34av(a)	2500	0.7	25
35av(a)	2500	0.7	25
61av	590	0.65	36

(a) manufacturer specifications

Table 3.3 Velocimeter Characteristics

Gauge	Natural Frequency (Hz)	Time to 0.5 Amplitude (s)	Calibration Temperature (°C)	Operate Temperature (°C)	System Range (m/s)
21uv	3.823	30.37	26.93	28.03	60
22uv	4.068	18.51	26.12	23.01	32
23uv	3.308	14.18	26.62	23.67	20
24uv	3.463	9.76	26.57	21.97	12
25uv	3.619	8.80	26.51	10.47	12
61uv	3.553	9.46	24.76	8.41	12

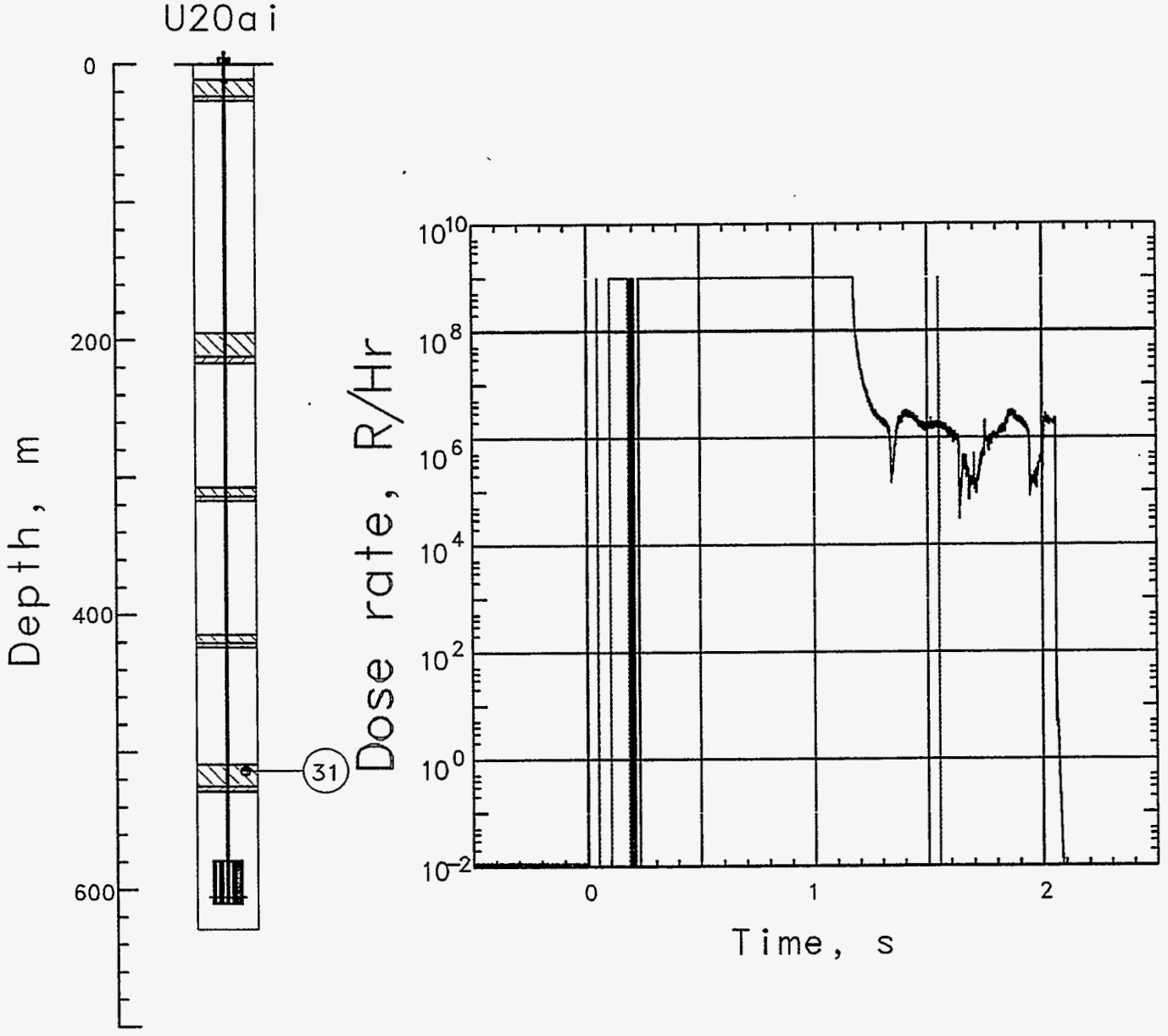


Figure 3.1 Radiation measured in the first SGC plug (station 31 at 516.6 m depth). Station signals were lost at about 2 s after detonation. There was no pressure transducer installed at this station.

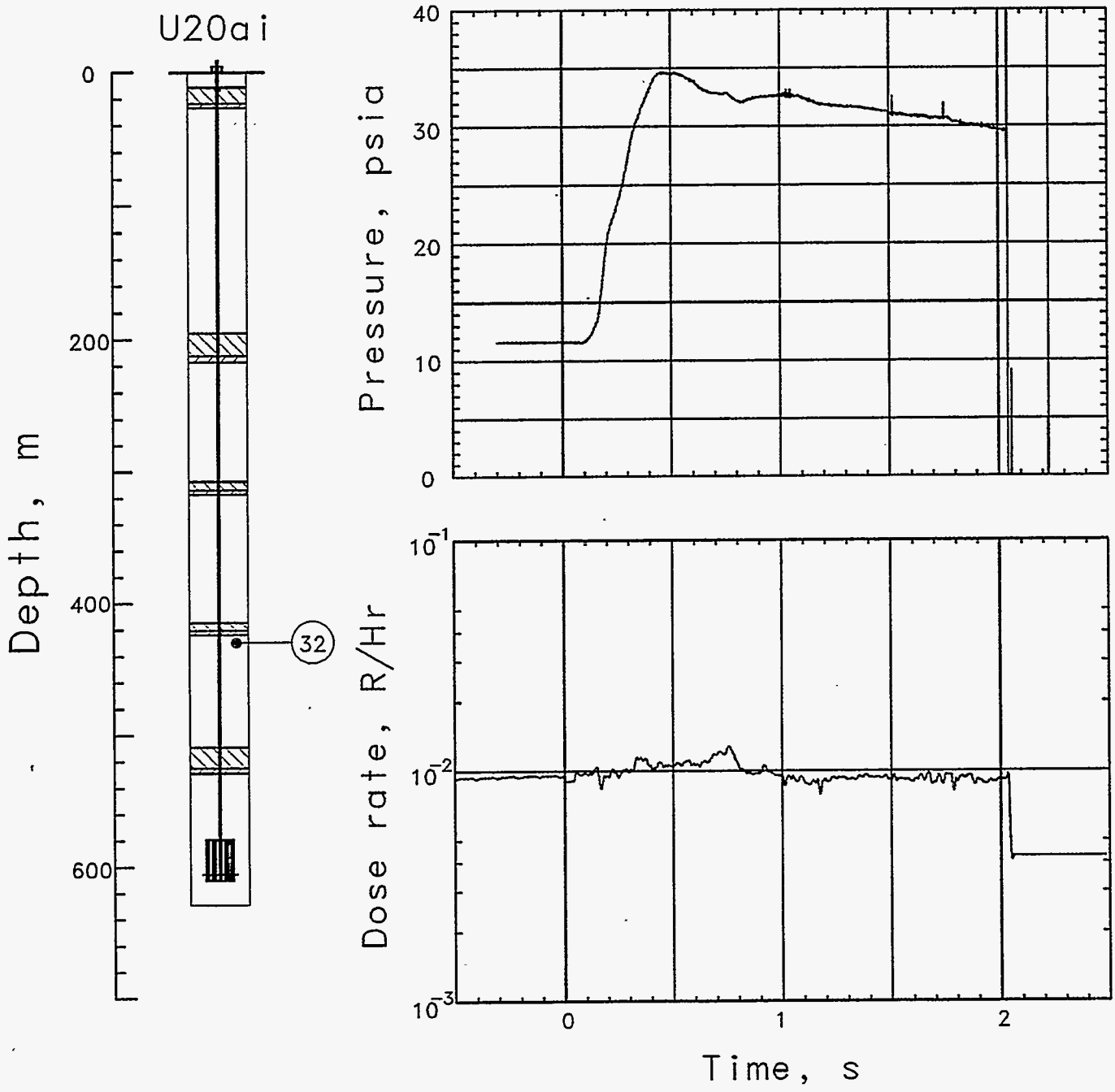


Figure 3.2 Pressure and radiation measured in the course stemming below the second SGC plug (station 32 at 466.3 m depth). Station signals were lost at about 2.1 s after detonation.

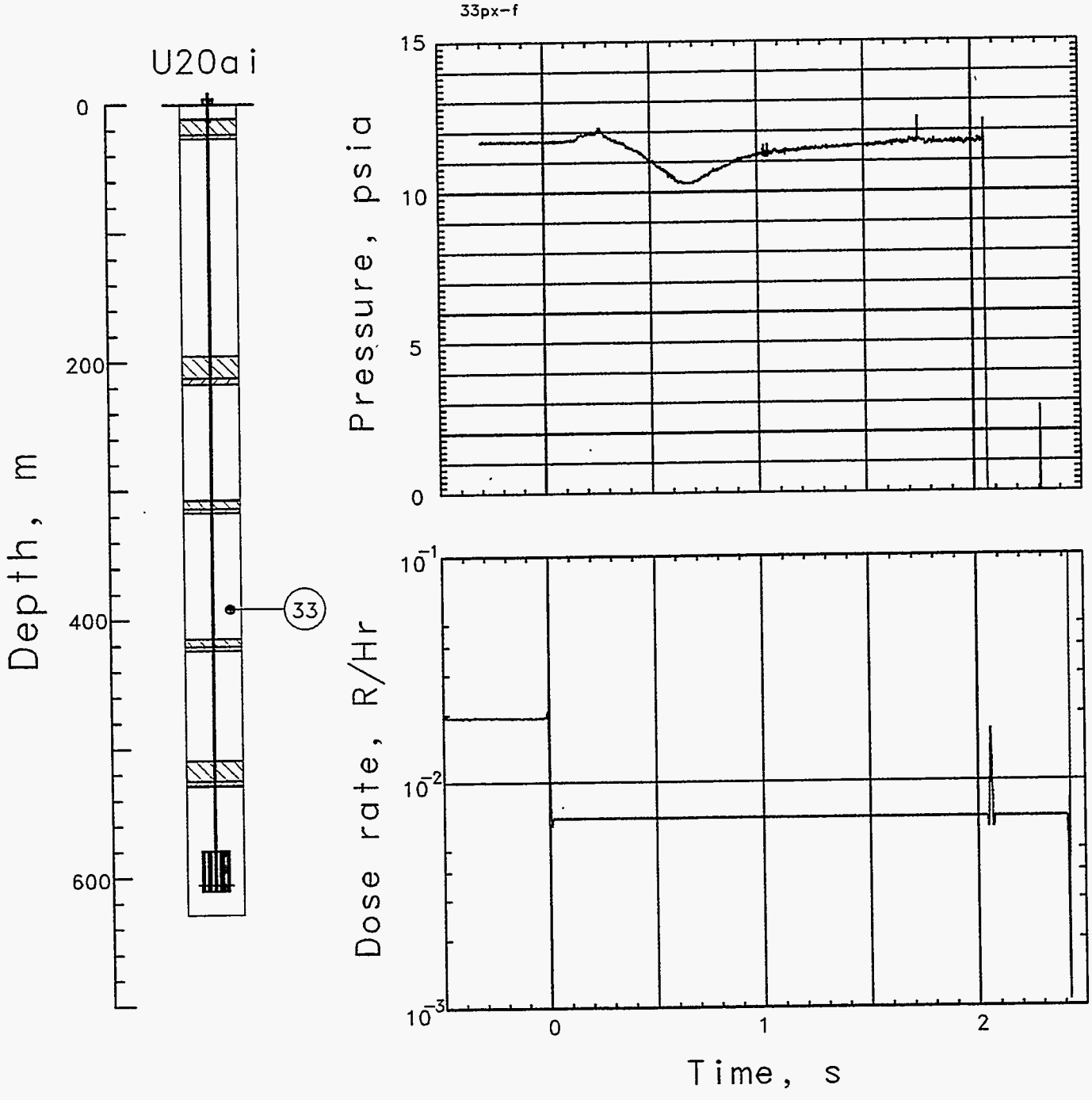


Figure 3.3 Pressure and radiation measured in the coarse stemming below the third SGC plug (station 33 at 390.1 m depth). Station signals were lost at about 2.1 s after detonation.

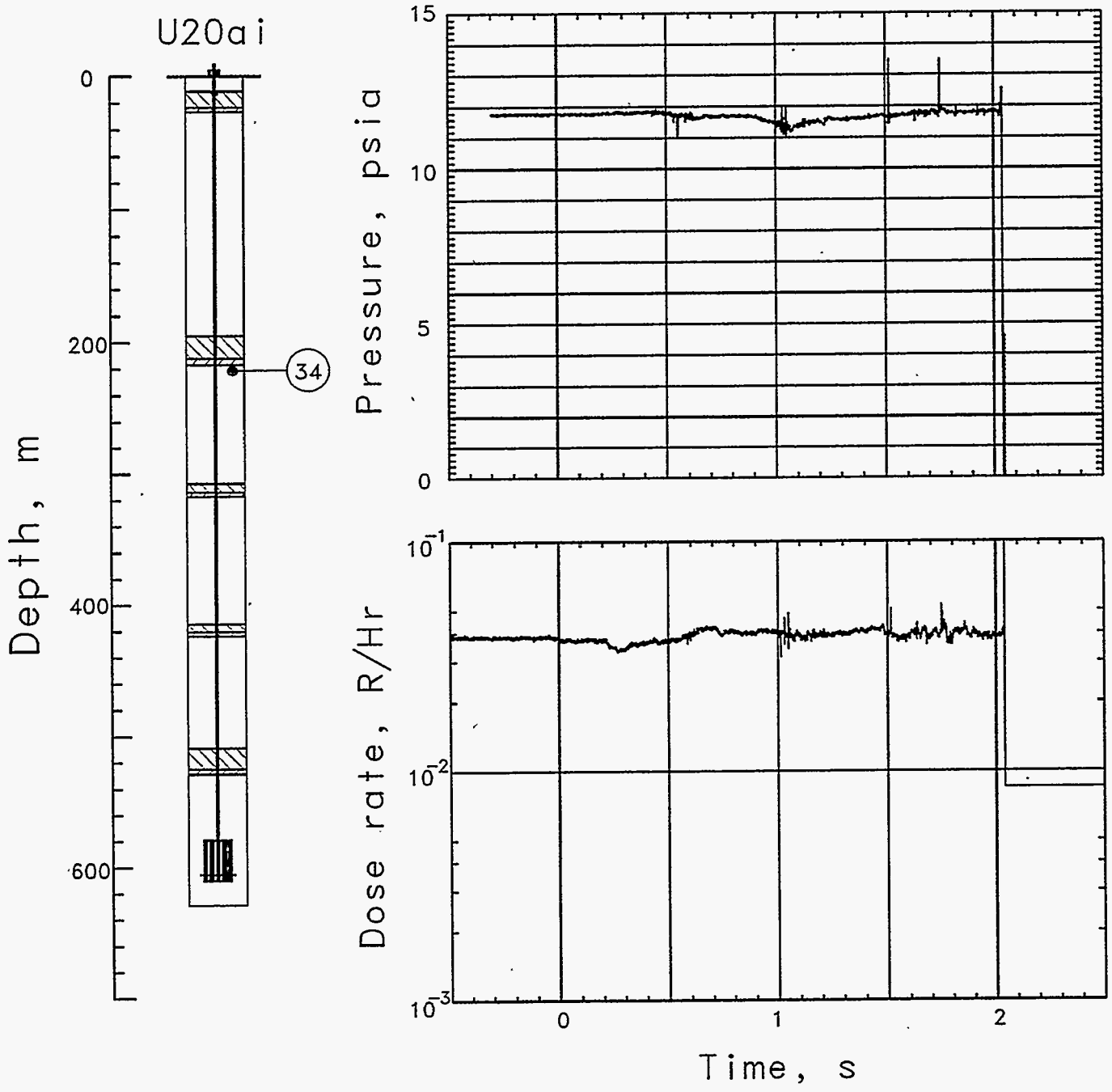


Figure 3.4 Pressure and radiation measured in the coarse stemming below the fourth SGC plug (station 34 at 221.0 m depth). Station signals were lost at about 2.1 s after detonation.

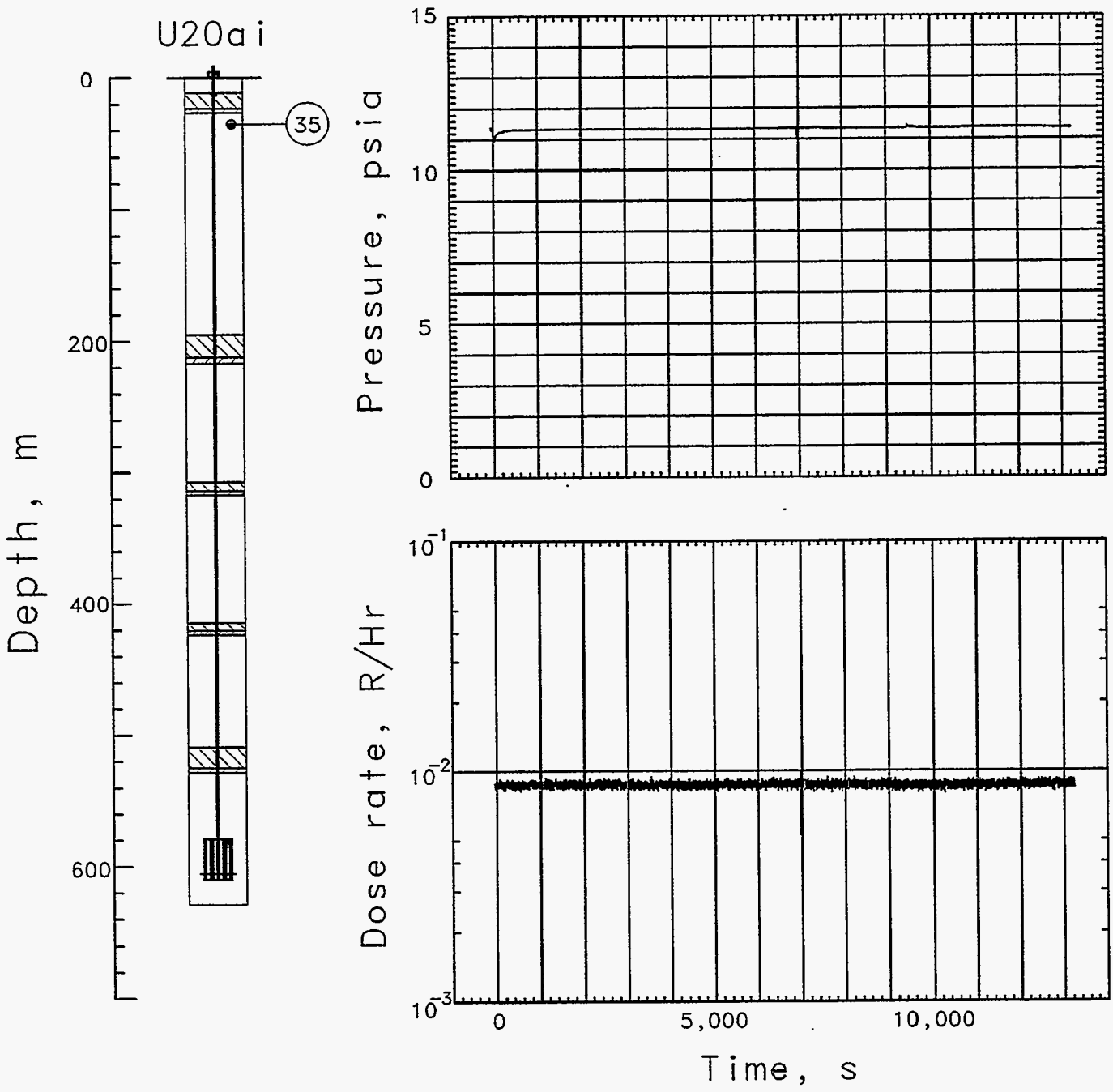


Figure 3.5 Pressure and radiation measured in the coarse stemming below the fifth SGC plug (station 35 at 31.4 m depth). The pressure drop at zero time is due to shock–induced ground motion and the jump in pressure at about 9500 s is associated with the subsurface collapse.

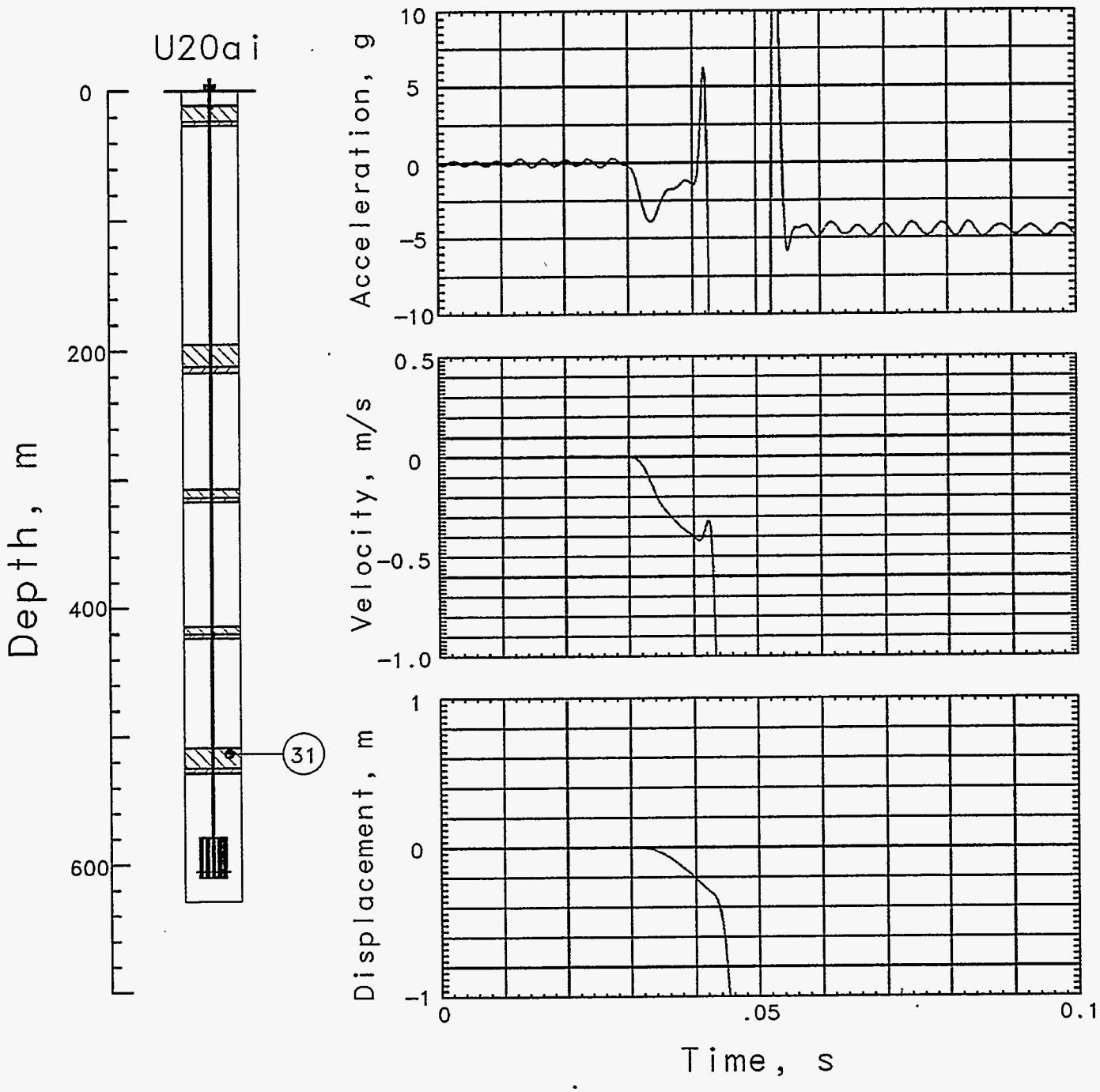


Figure 3.6 Explosion–induced vertical motion of the bottom plug at a depth of 516.6 m (station 31). The data are invalid after 42 ms. The anomalous negative–going initial motion is unexplained.

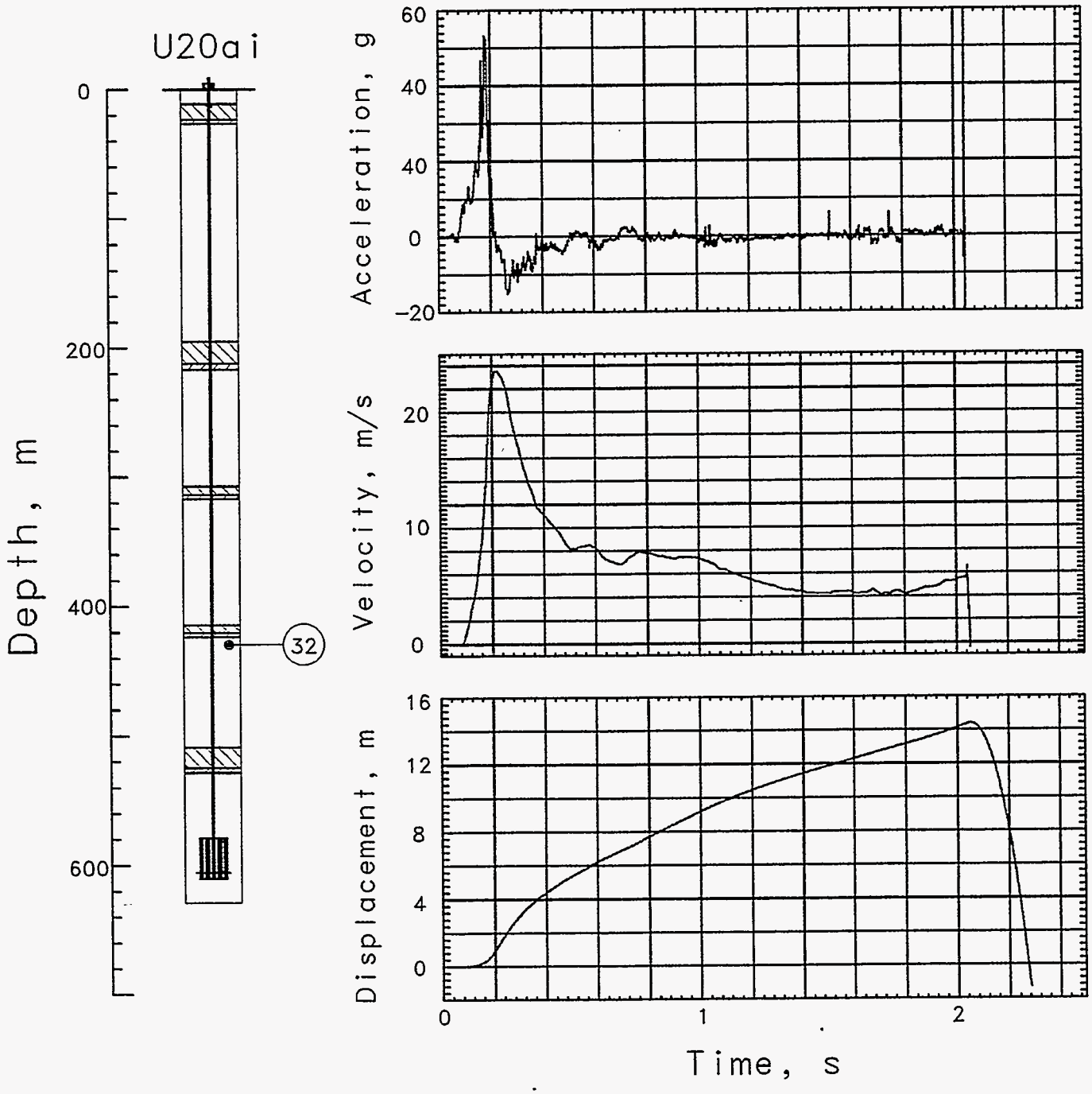


Figure 3.7 Explosion–induced vertical motion in the coarse stemming of the emplacement hole at a depth of 466.3 m (station 32). Station signals were lost at about 2.1 s after detonation.

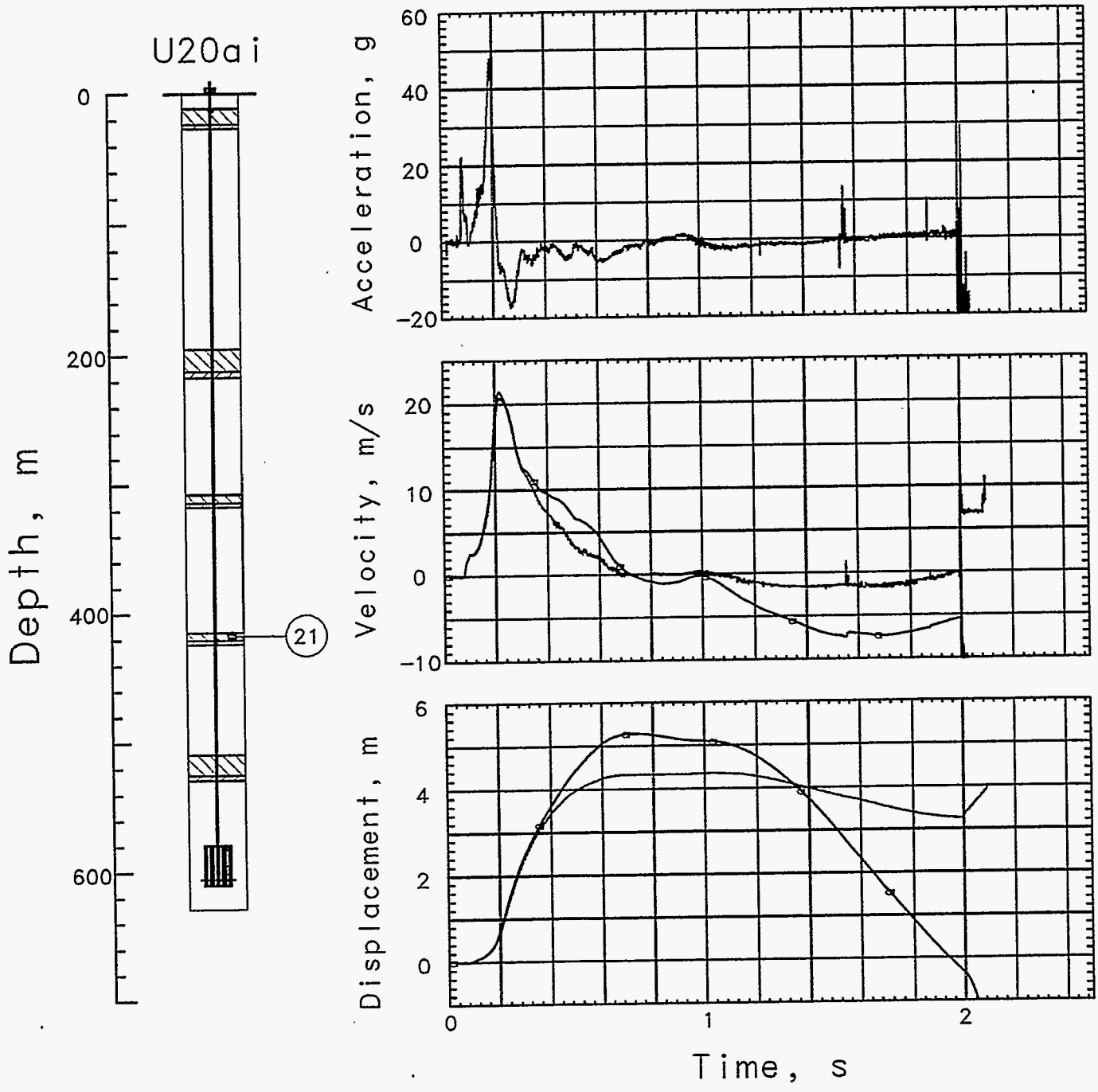


Figure 3.8 Explosion–induced vertical motion of the second plug at a depth of 417.6 m (station 21). Station signals were lost at about 2.0 s after detonation. Data records annotated with an "a" were obtained from an accelerometer.

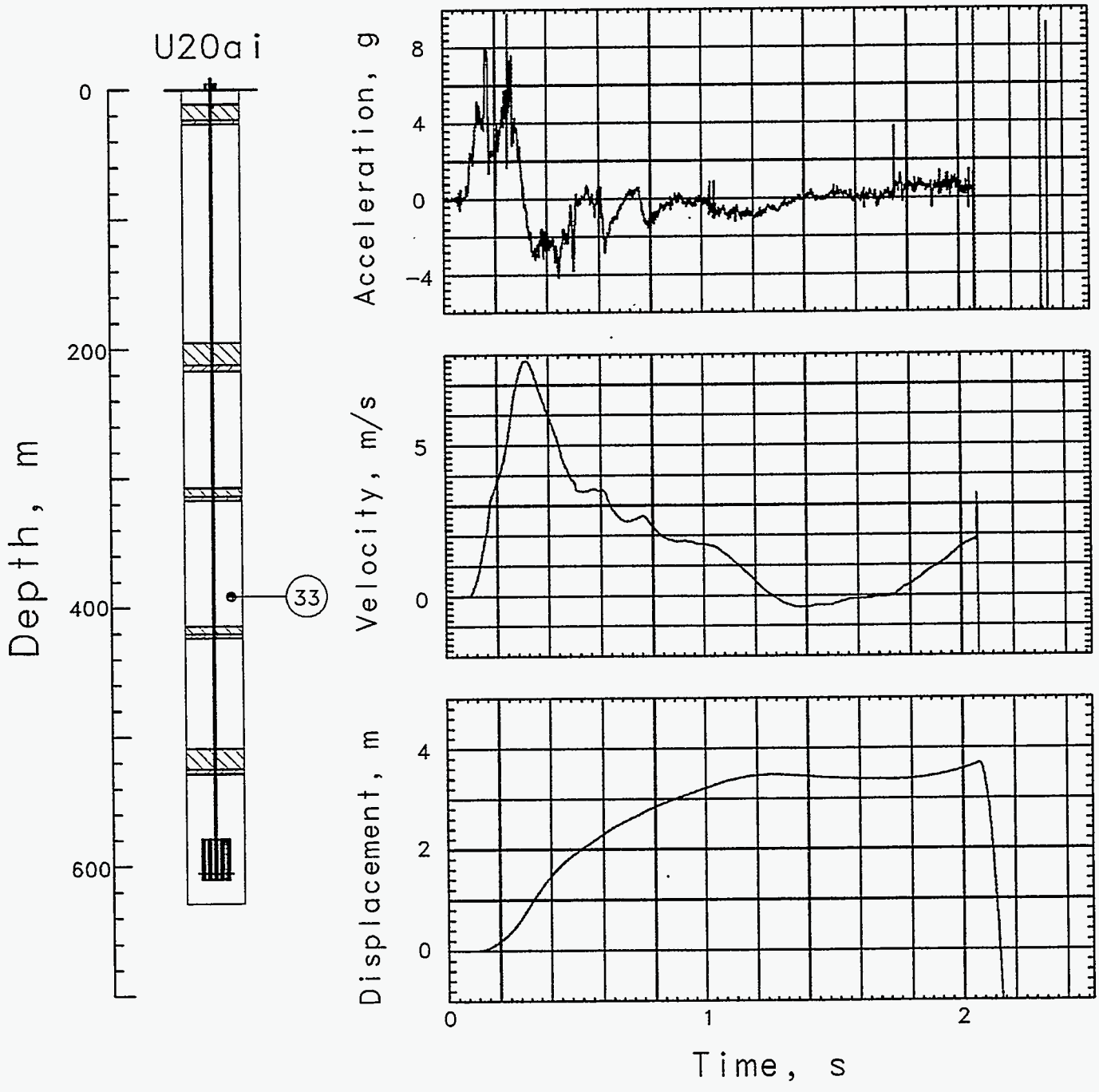


Figure 3.9 Explosion–induced vertical motion in the coarse stemming of the emplacement hole at a depth of 390.1 m (station 33). Station signals were lost at about 2.1 s after detonation.

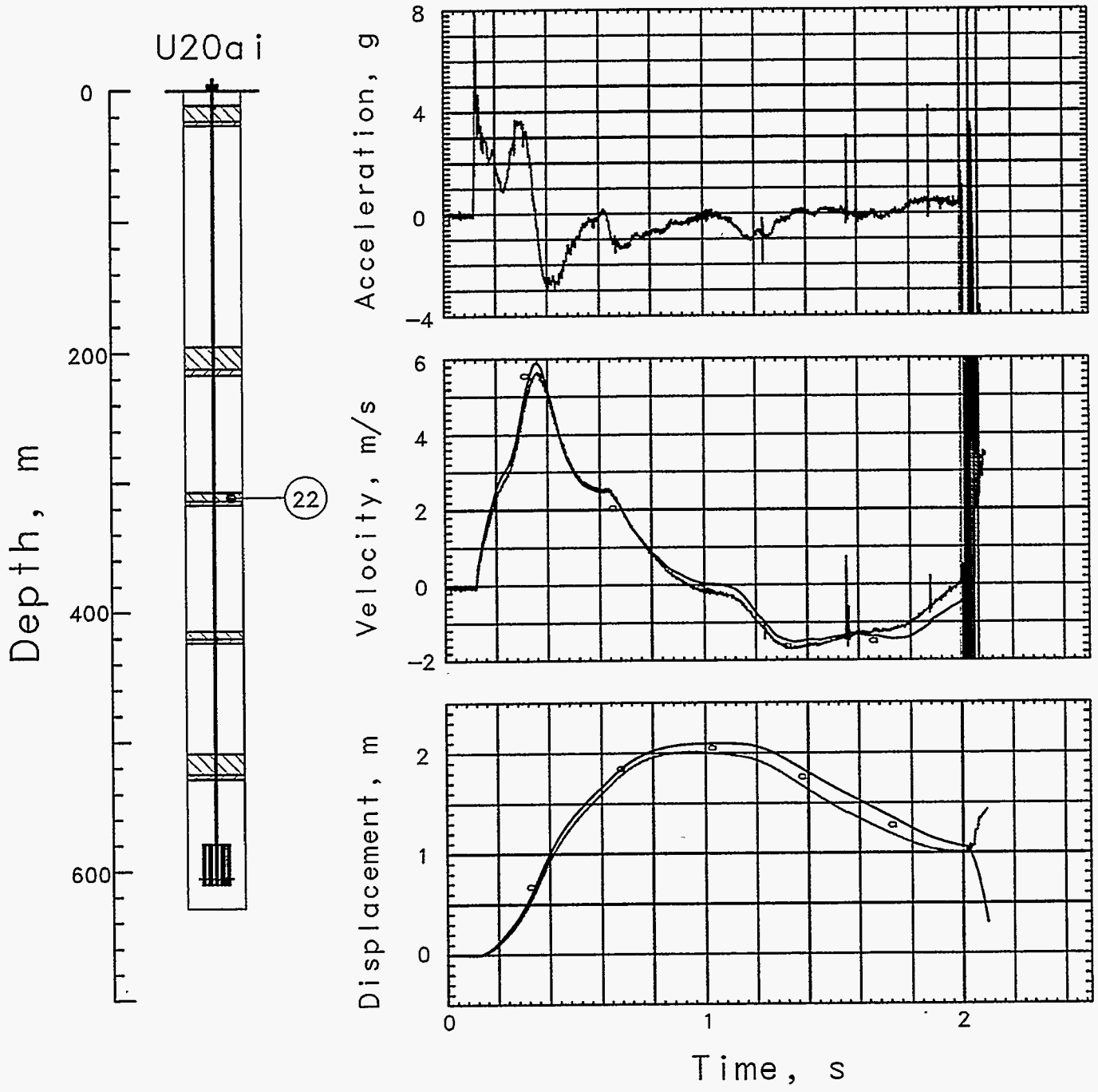


Figure 3.10 Explosion–induced vertical motion of the third plug at a depth of 310.9 m (station 22). Station signals were lost at about 2.0 s after detonation. Data records annotated with an "a" were obtained from an accelerometer.

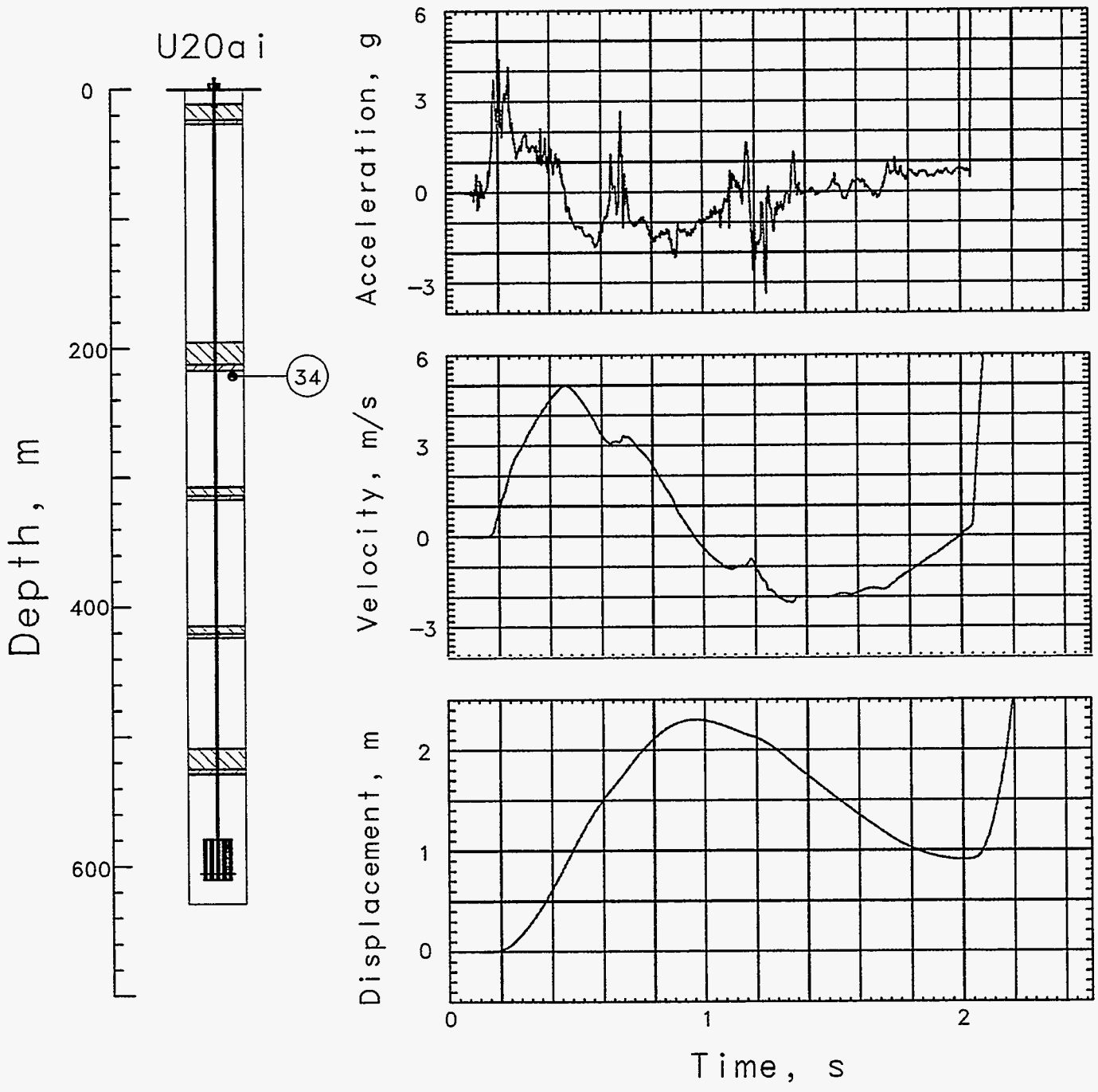


Figure 3.11 Explosion–induced vertical motion in the coarse stemming of the emplacement hole at a depth of 221.0 m (station 34). Station signals were lost at about 2.1 s after detonation.

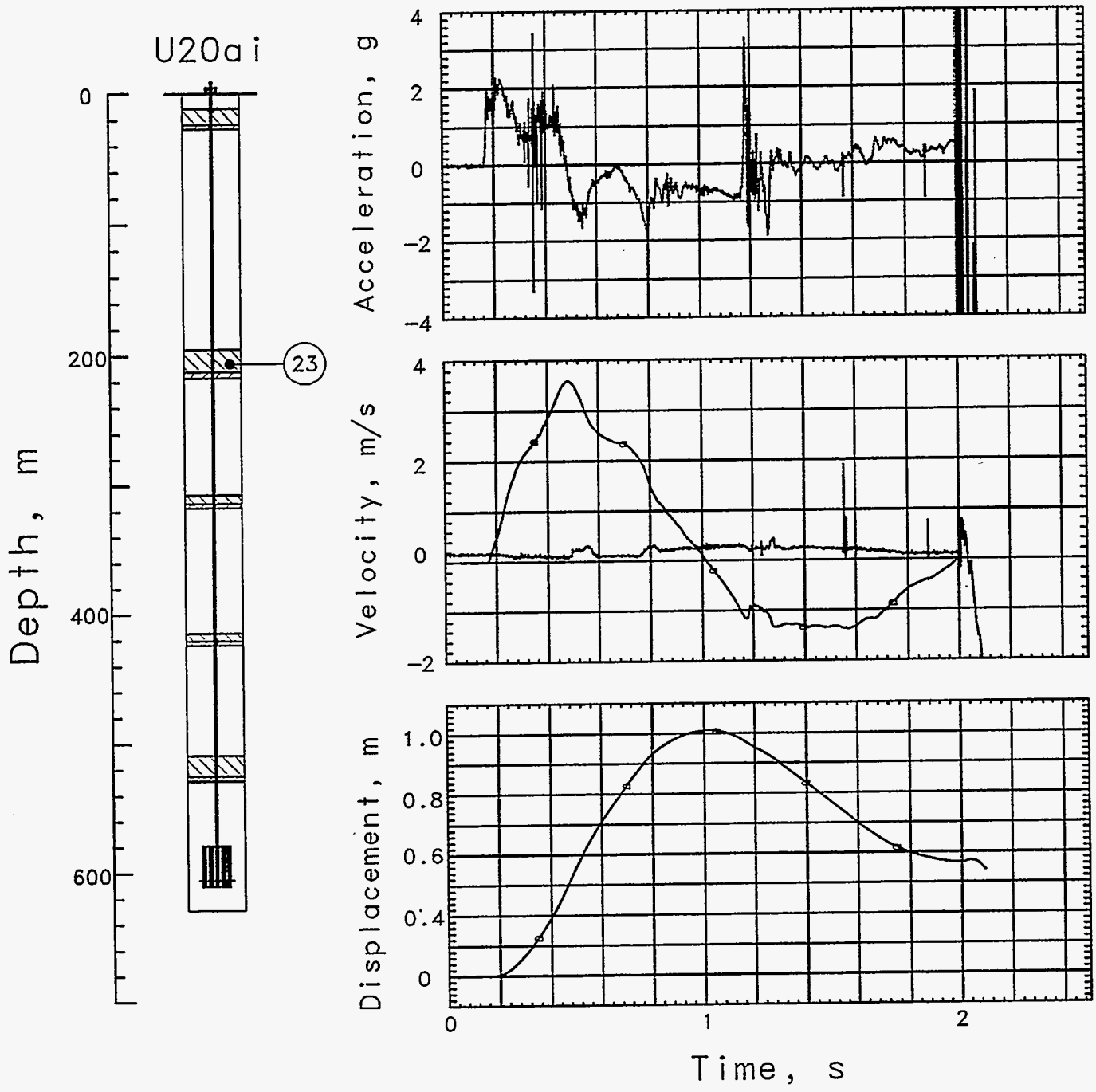


Figure 3.12 Explosion–induced vertical motion of the fourth plug at a depth of 207.3 m (station 23). Station signals were lost at about 2.0 s after detonation. Data records annotated with an "a" were obtained from an accelerometer. The associated velocimeter at this station was apparently inoperative pre–shot.

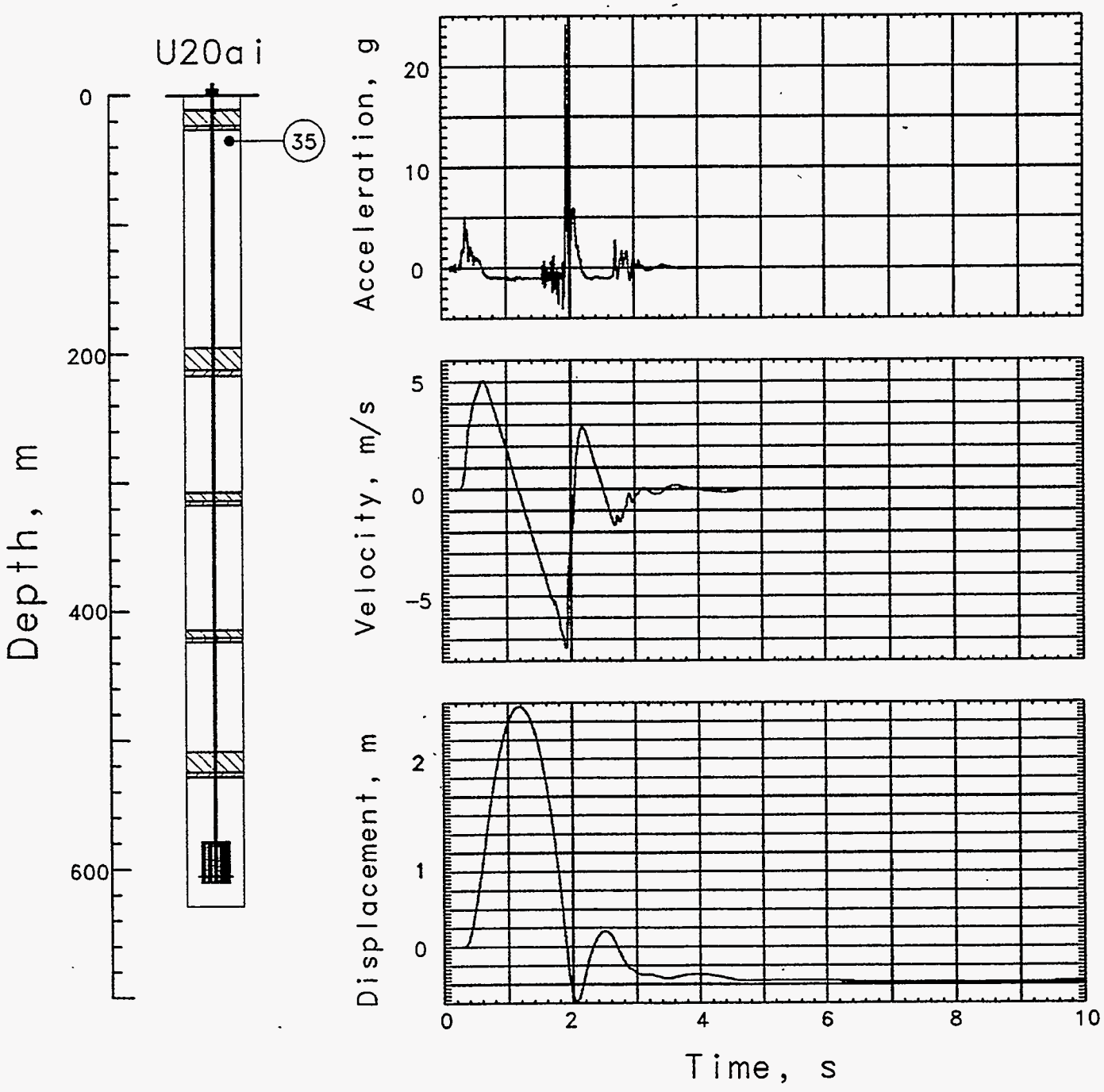


Figure 3.13 Explosion–induced vertical motion in the coarse stemming of the emplacement hole at a depth of 31.4 m (station 35). This is the only station for which the final explosion–induced displacement could be derived.

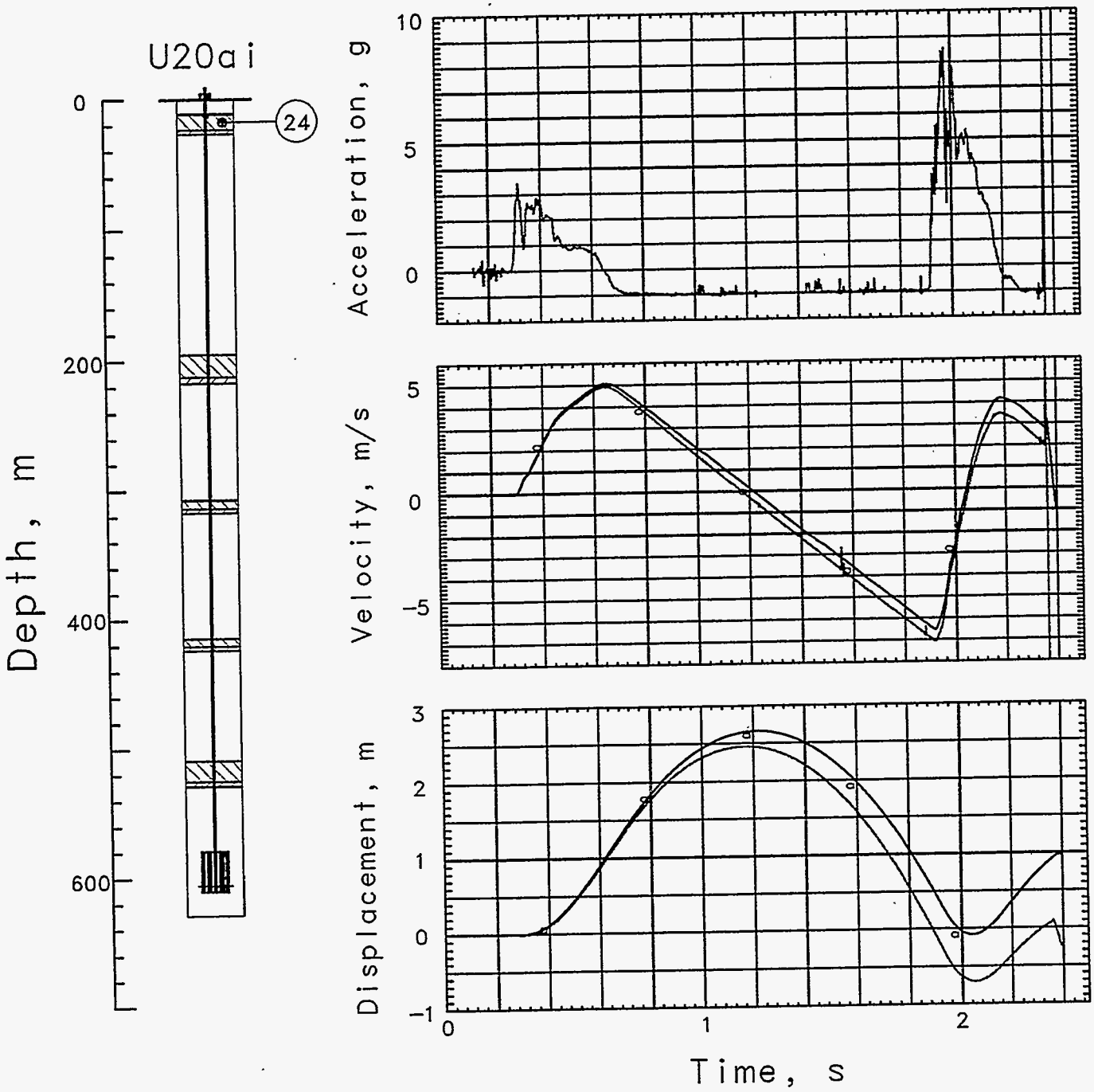


Figure 3.14 Explosion–induced vertical motion of the fifth plug at a depth of 17.7 m (station 24). Station signals were interrupted at about 2.4 s after detonation. Data records annotated with an "a" were obtained from an accelerometer.

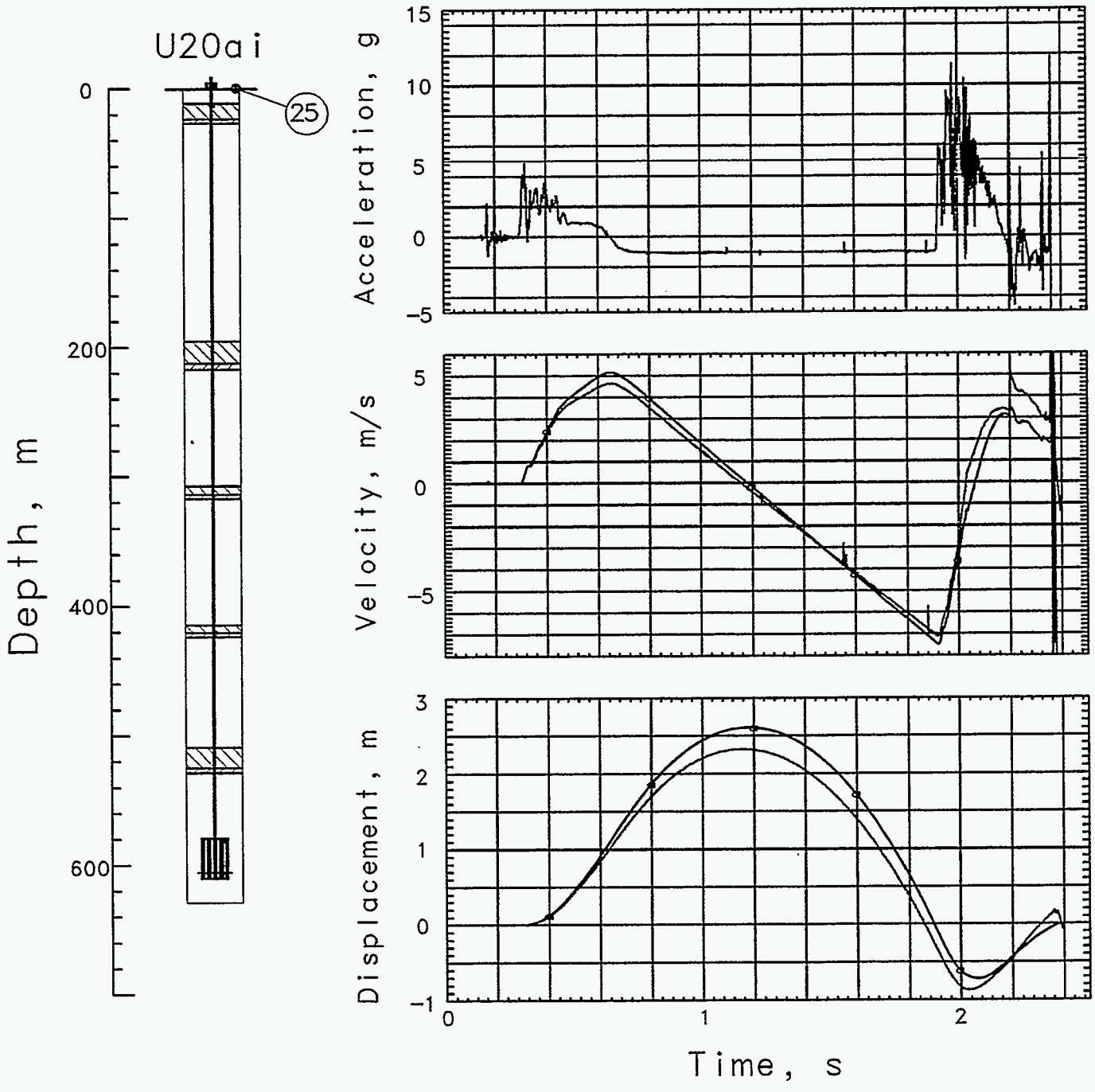


Figure 3.15 Explosion–induced vertical motion of the surface casing (station 25). Station signals were interrupted at about 2.4 s after detonation. Data records annotated with an "a" were obtained from an accelerometer.

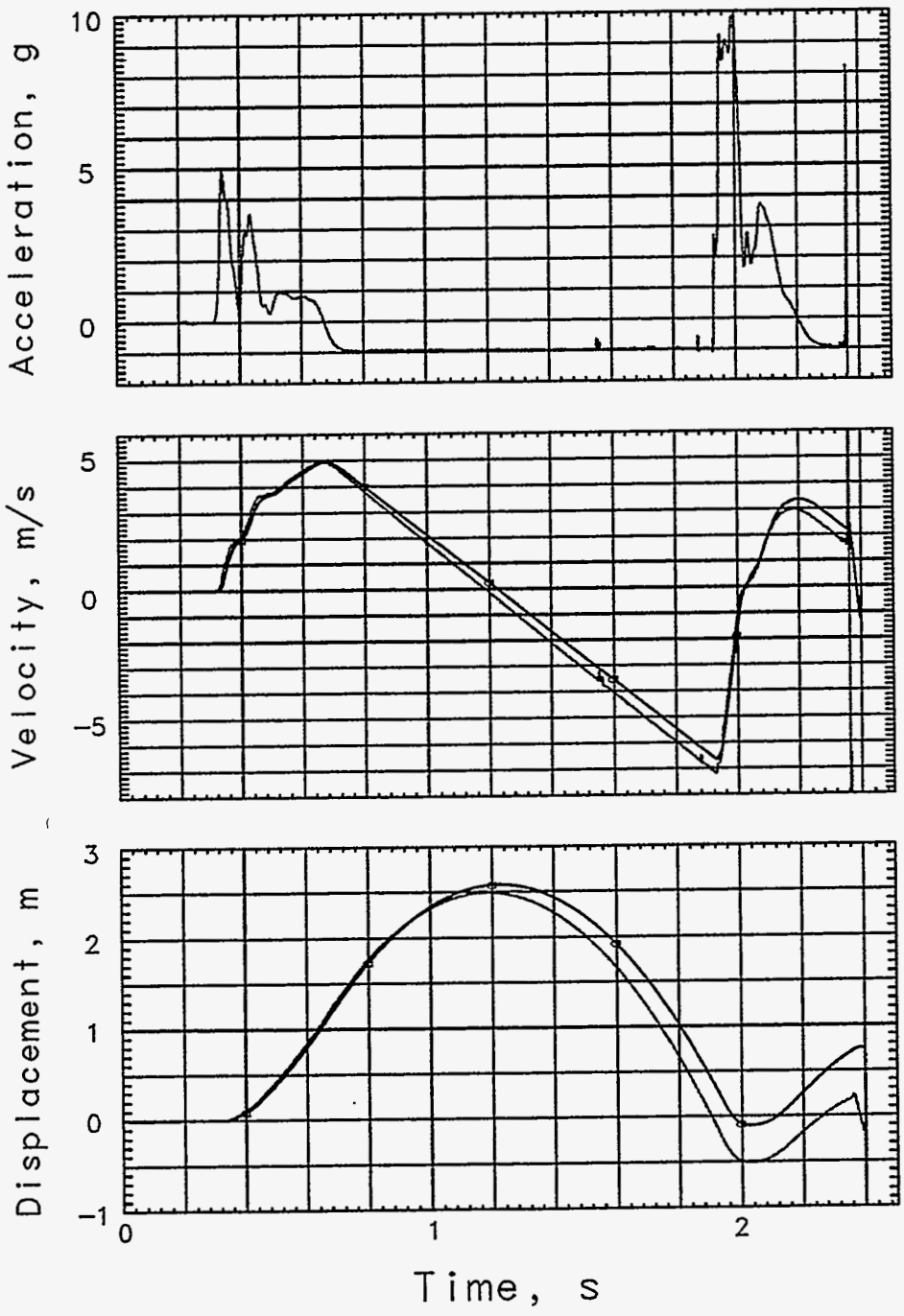


Figure 3.16 Explosion–induced vertical motion 0.91 m deep in the ground surface at a horizontal distance of 15.24 m from Surface Ground Zero (station 61). Station signals were interrupted at about 2.4 s after detonation. Data records annotated with an 'a' are derived from the accelerometer.

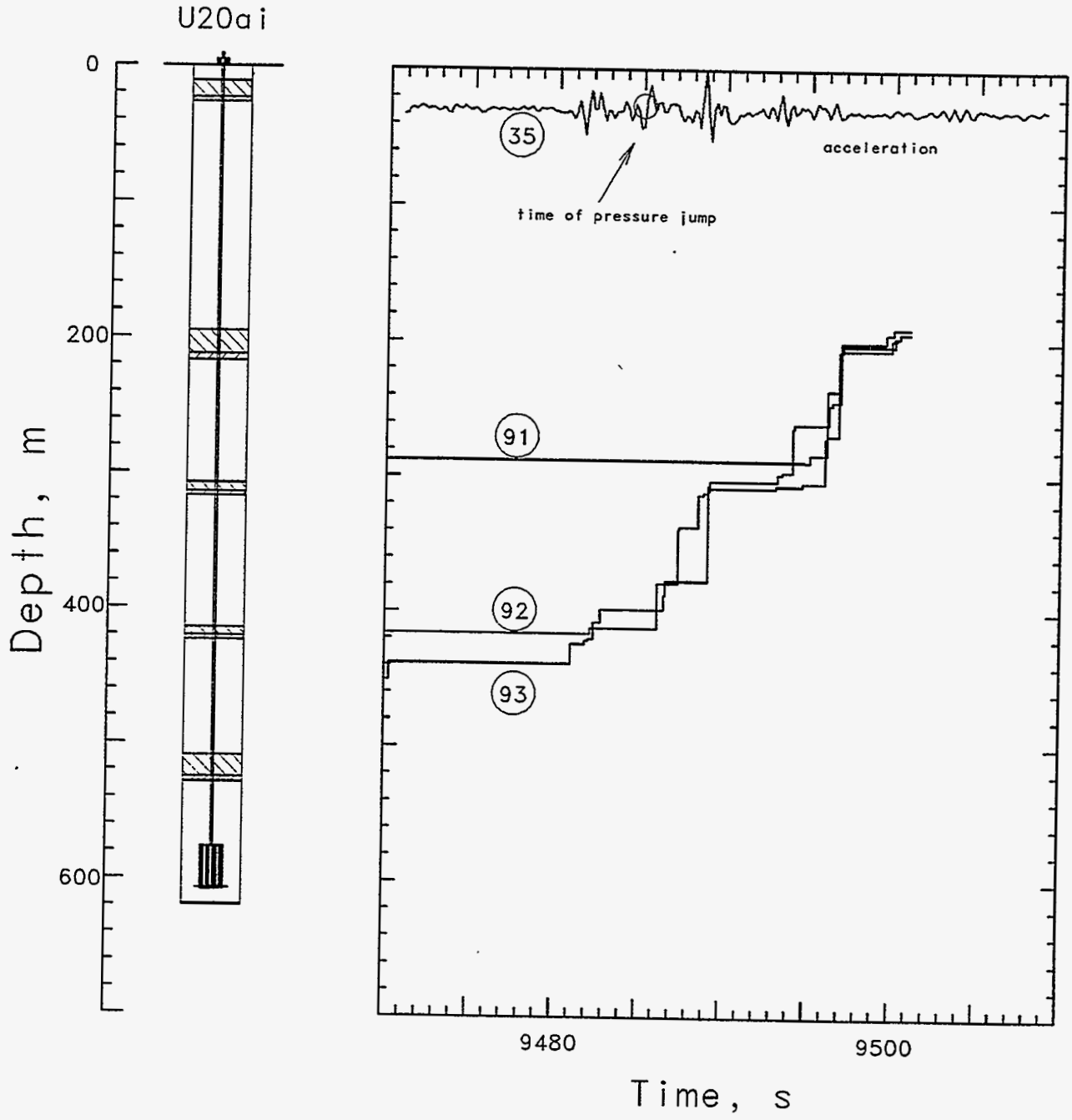


Figure 3.17 Collapse history as indicated by breaks in the EXCOR cables (stations 91, 92 and 93). The datum indicated by the circle indicates the time (9485 s) at which the pressure at station 35 increases by about 0.1 psi (see figure 3.5). Also shown is the acceleration history from station 35 at the approximate depth of the station (see figure 3.18).

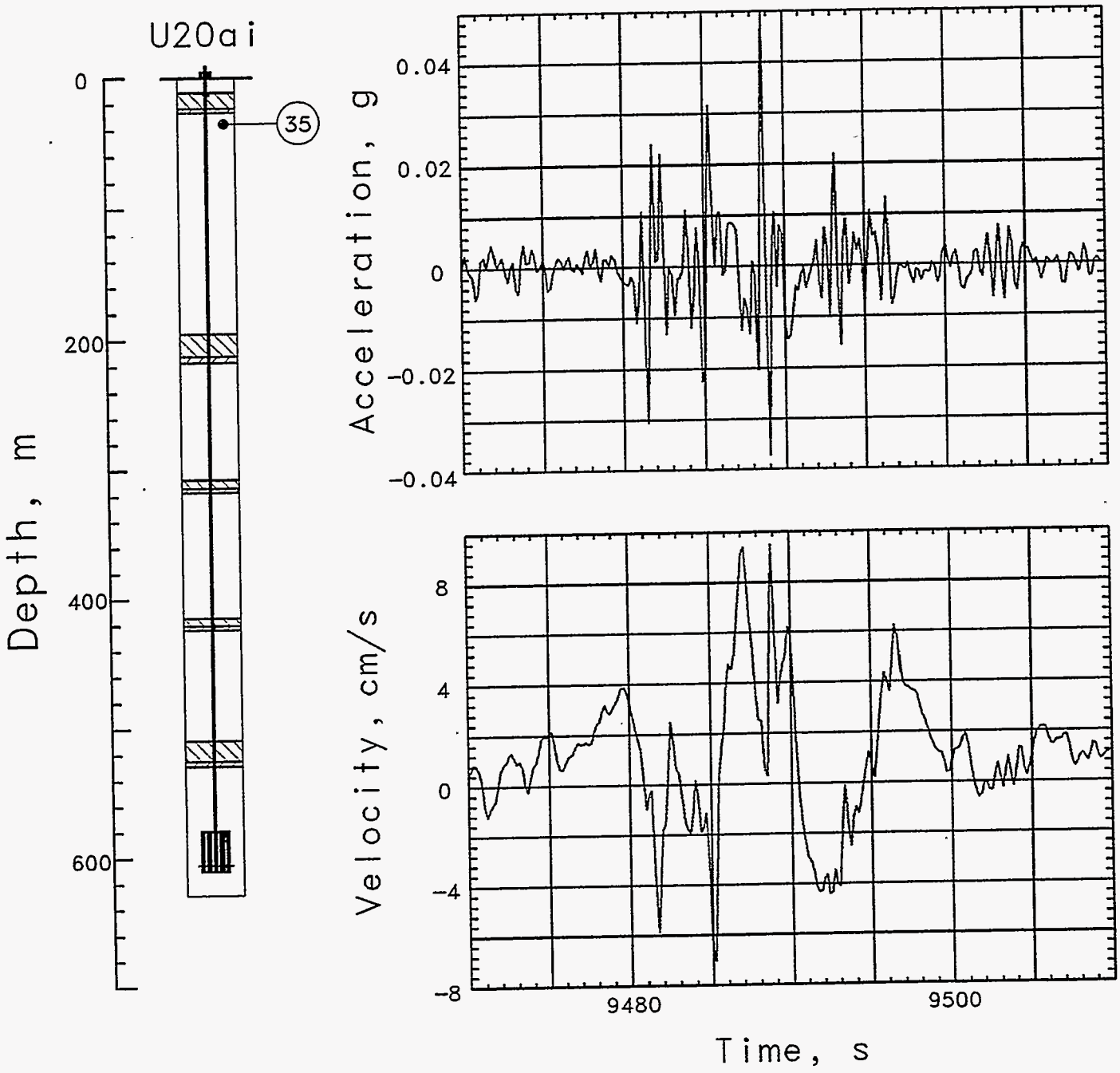


Figure 3.18 Collapse–induced vertical motion in the coarse stemming of the emplacement hole at a depth of 31.4 m (station 35). The acceleration is integrated once to velocity: the record is not of good enough quality to obtain meaningful displacement.

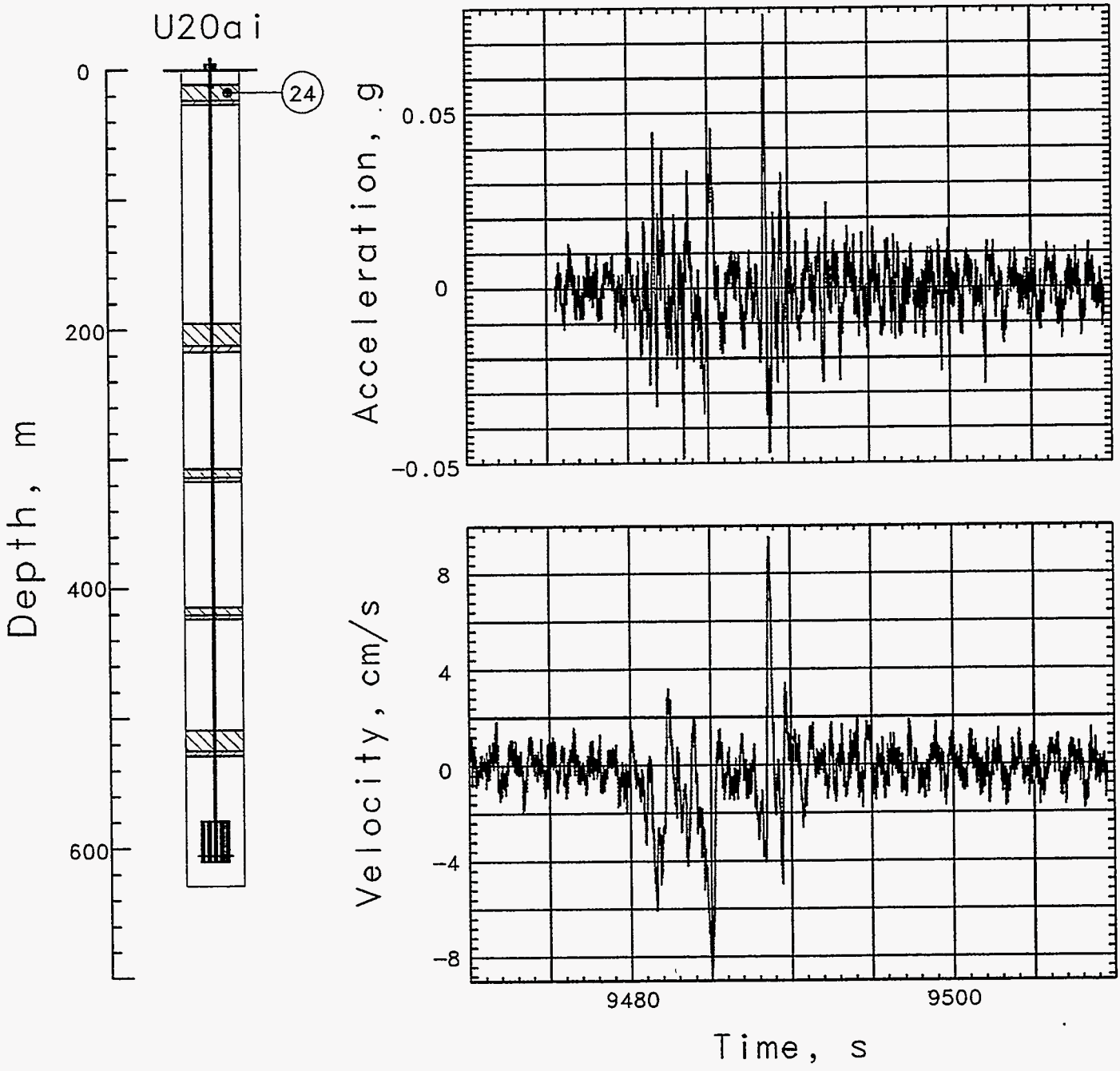


Figure 3.19 Collapse–induced vertical motion of the top plug at a depth of 17.7 m (station 24). Only the measured acceleration and velocity are presented.

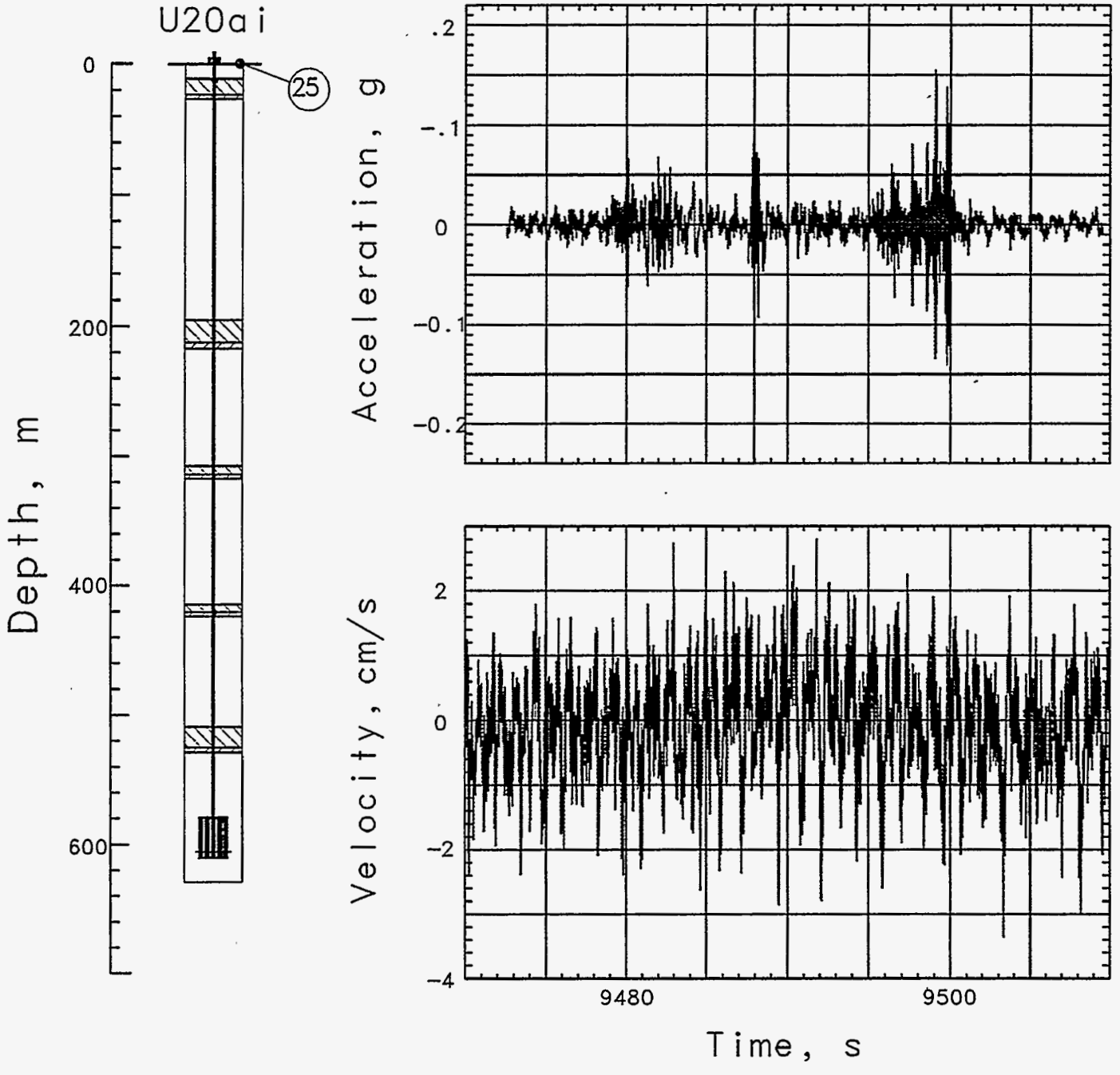


Figure 3.20 Collapse–induced vertical motion of the surface casing (station 25). Only the measured acceleration and velocity are presented.

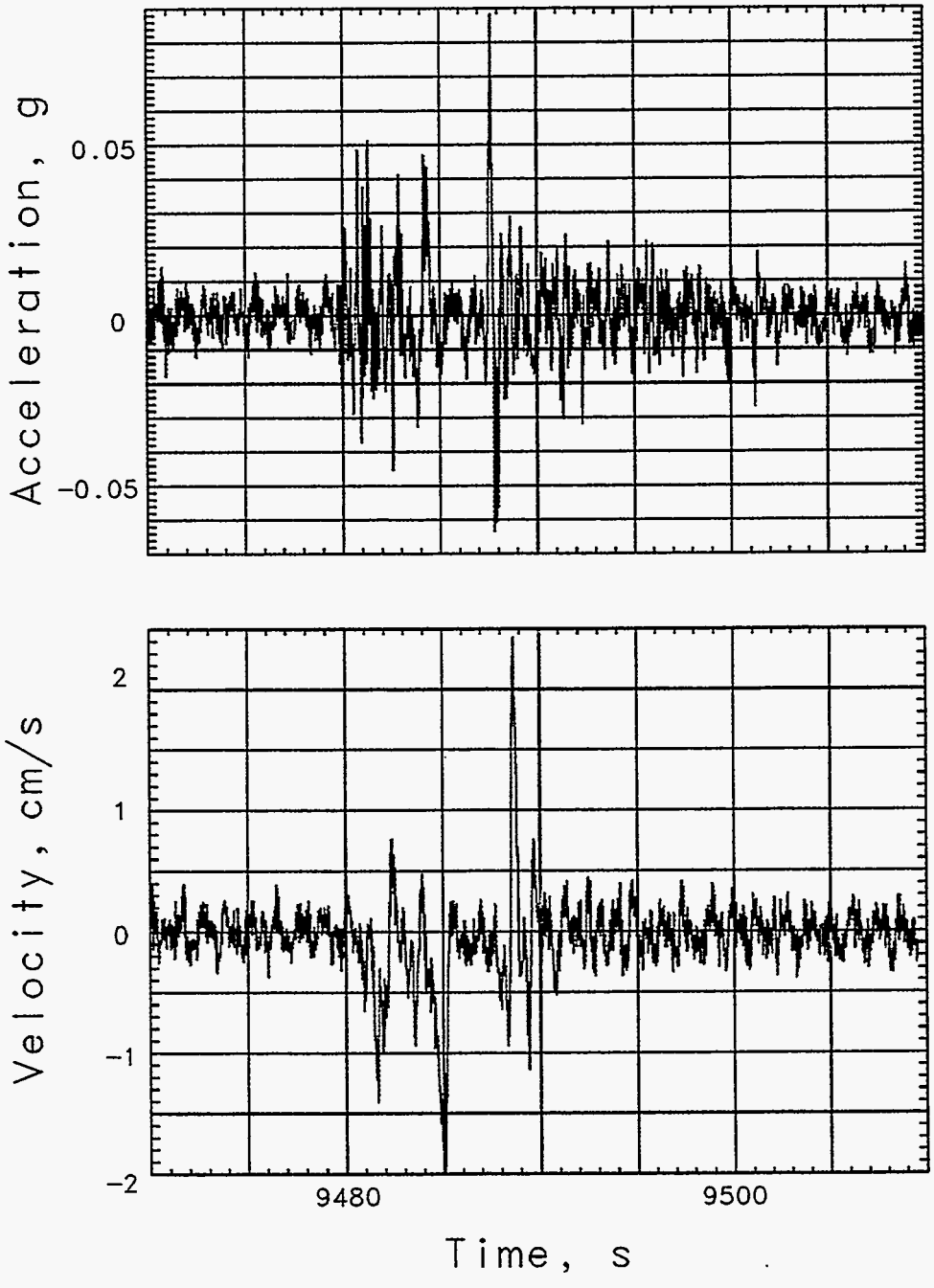


Figure 3.21 Collapse–induced vertical motion 0.91 m deep in the ground surface at a horizontal distance of 15.24 m from Surface Ground Zero (station 61). Only the measured acceleration and velocity are presented.

4. Other Measurements

4.1 Motion in the LLNL trailer park

Figure 4.1 shows data as recorded on a high sensitivity accelerometer and a geophone mounted in the ground surface of the trailer park (station 62). Included is the entire recording period from a few minutes before detonation to a few minutes after subsurface subsidence. The low seismic activity from JEFFERSON is evident from these records.

Triaxial motion of the recording trailer is shown in figures 4.2–4.4. Motion sensed during the collapse episode at about 5740 s was of too low an amplitude for meaningful reduction and is not shown.

4.2 Permeability data

As part of a continuing investigation of the permeability of the upper geologic layers of the Nevada Test Site, sensitive pressure transducers were fielded in the emplacement hole beneath each of the two upper SGC plugs. One station was below the fifth plug and two were in the coarse stemming beneath the top plug and a fourth was placed 0.61 m deep in the ground surface 15.2 m from Surface Ground Zero. Data were digitally recorded from about 2 months prior to the event to event time and are shown in figure 4.5.

4.2 Stress and strain

Radial and transverse stress and strain were monitored at two locations in the bottom plug using transducers (developed by Dynasen, Inc.[6]) which, in principal, allow the removal of the strain contribution to the record of the stress transducer. Each location was monitored with transducer packages, each containing two elements (one being Ytterbium and the other constantan) having initial unstrained resistances of about 300 Ω. The elements were coupled to the stress field with a thin layer of fluid in an attempt to preclude inhomogenietes introduced by the required cladding on the package. Figures 4.5 and 4.6 show the fractional resistance change (% $\Delta R/R$) histories obtained from these instruments. Only three of the eight elements between these two stations survived the shock arrival (at about 48 ms) with all signals being lost just after 100 ms. The EMP introduced a large signal component on each of the channels, lasting at least until shock arrival. This casts doubt on the usefulness of the information from those elements that survived the shock.

Table 4.1 Summary of Motion

Gauge	Slant Range (m)[a]	Arrival Time (ms)	Peak Acceleration (g)	Peak Velocity (m/s)	Peak Displacement (m)	Residual Displacement (cm)
71av	680[a]	398	2.1, 3.4[b]	1.6	0.60	(c)
71uv		-	-	2.4	0.48	-15
71ar	680[a]	387	3	0.9	0.67	(c)
71ur		-	-	1.4	1.13	(c)
71at	680[a]	385	0.7	0.1, 0.27	0.06[c]	(c)
71ut		-	-	0.08, 0.25	0.033[c]	(c)

(a) Range is approximate: stations are in recording trailer.
(b) Slap-down peak.
(c) Signal lost before final value attained.

Table 4.2 Accelerometer Characteristics

Gauge	Natural Frequency (Hz)	Damping Ratio	System Range (g's)
71av	330	0.70	20
71ar	340	0.70	15
71at	310	0.75	15

Table 4.3 Velocimeter Characteristics

Gauge	Natural Frequency (Hz)	Time to 0.5 Amplitude (s)	Calibration Temperature (°C)	Operate Temperature (°C)	System Range (m/s)
71uv	3.253	12.03	24.42	18.75	7
71ur	3.516	9.59	24.74	18,75	5
71ut	3.354	8.87	25.41	18.75	5

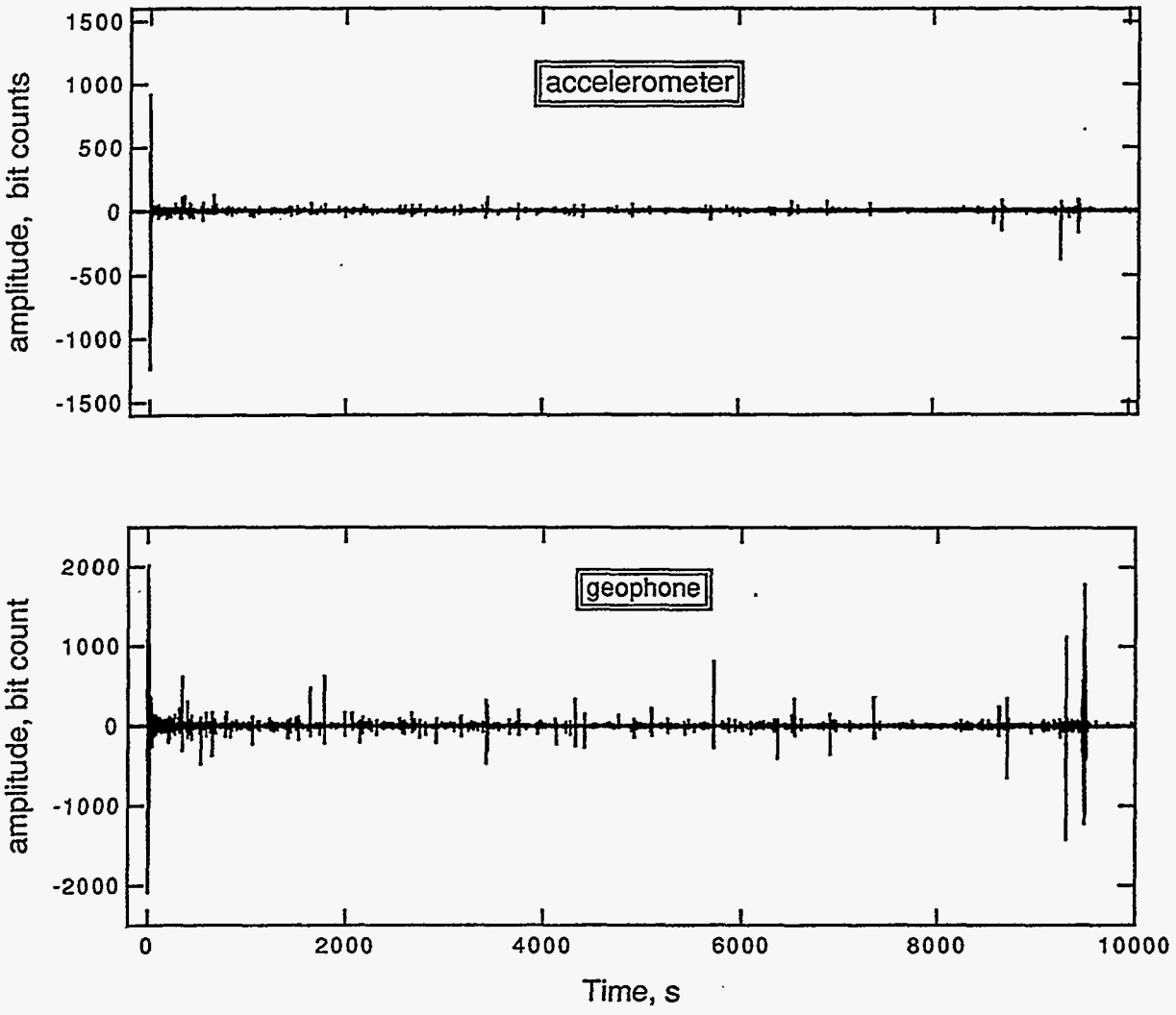


Figure 4.1 Data from the vertical geophone and sensitive accelerometer mounted in the ground surface at the recording trailer (station 62). Subsurface subsidence to a depth of about 190 m occurred at about 2hr, 37min.

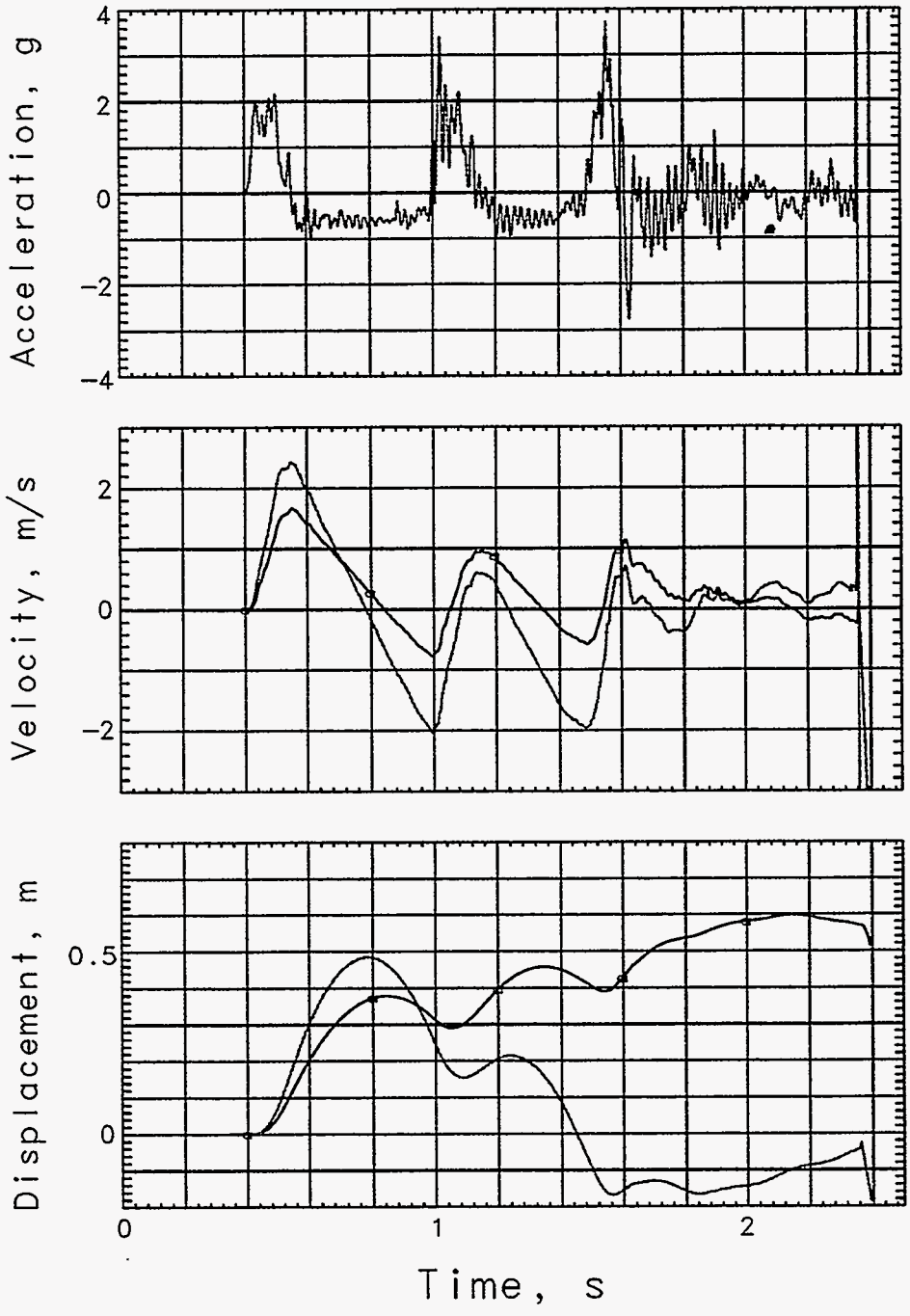


Figure 4.2 Explosion–induced vertical motion of the recording trailer (station 71). Data records annotated with an 'a' are derived from the accelerometer. Station signals were interrupted at about 2.4 s after detonation.

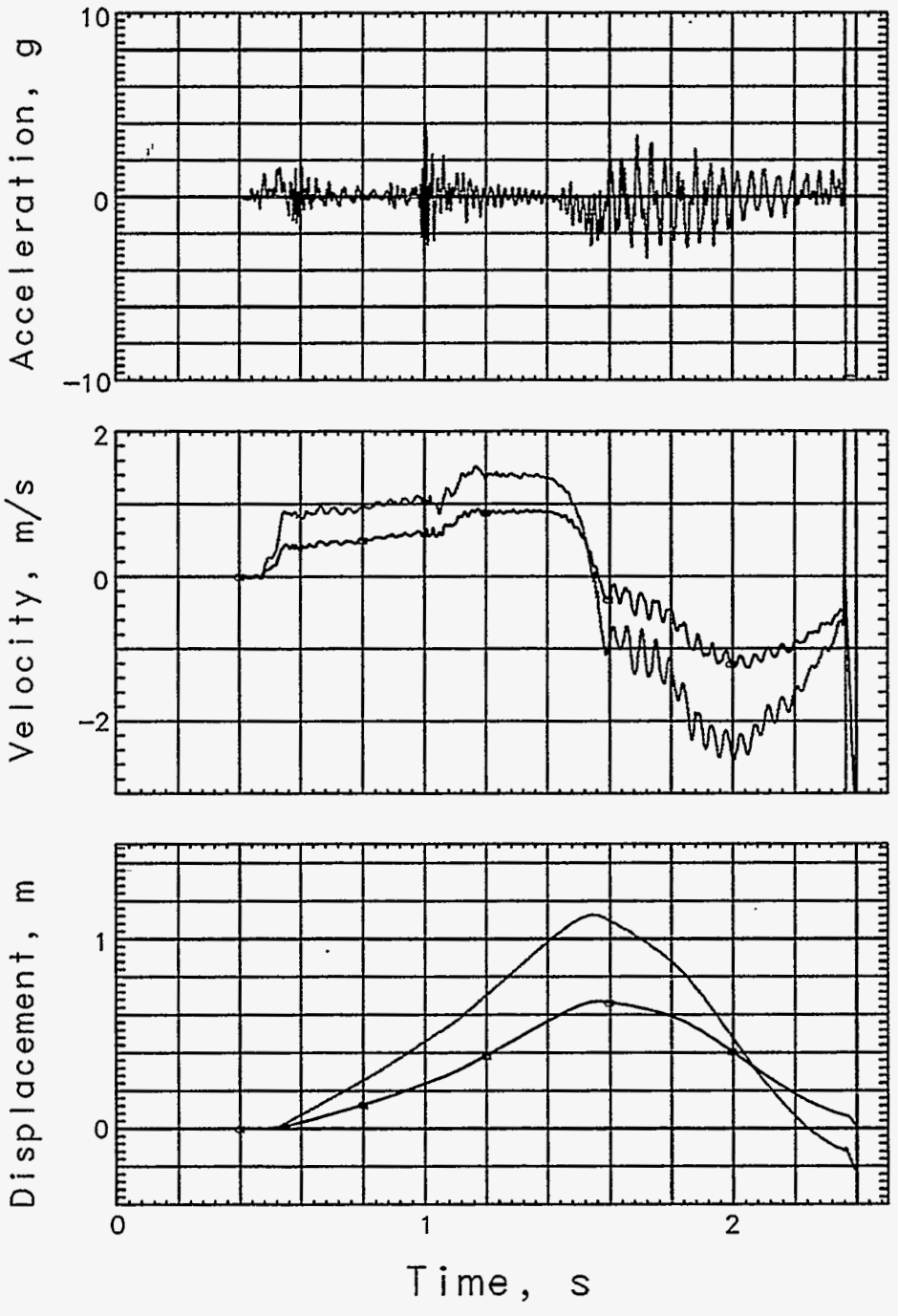


Figure 4.3 Explosion–induced horizontal–radial motion of the recording trailer (station 71). Data records annotated with an 'a' are derived from the accelerometer. Station signals were interrupted at about 2.4 s after detonation.

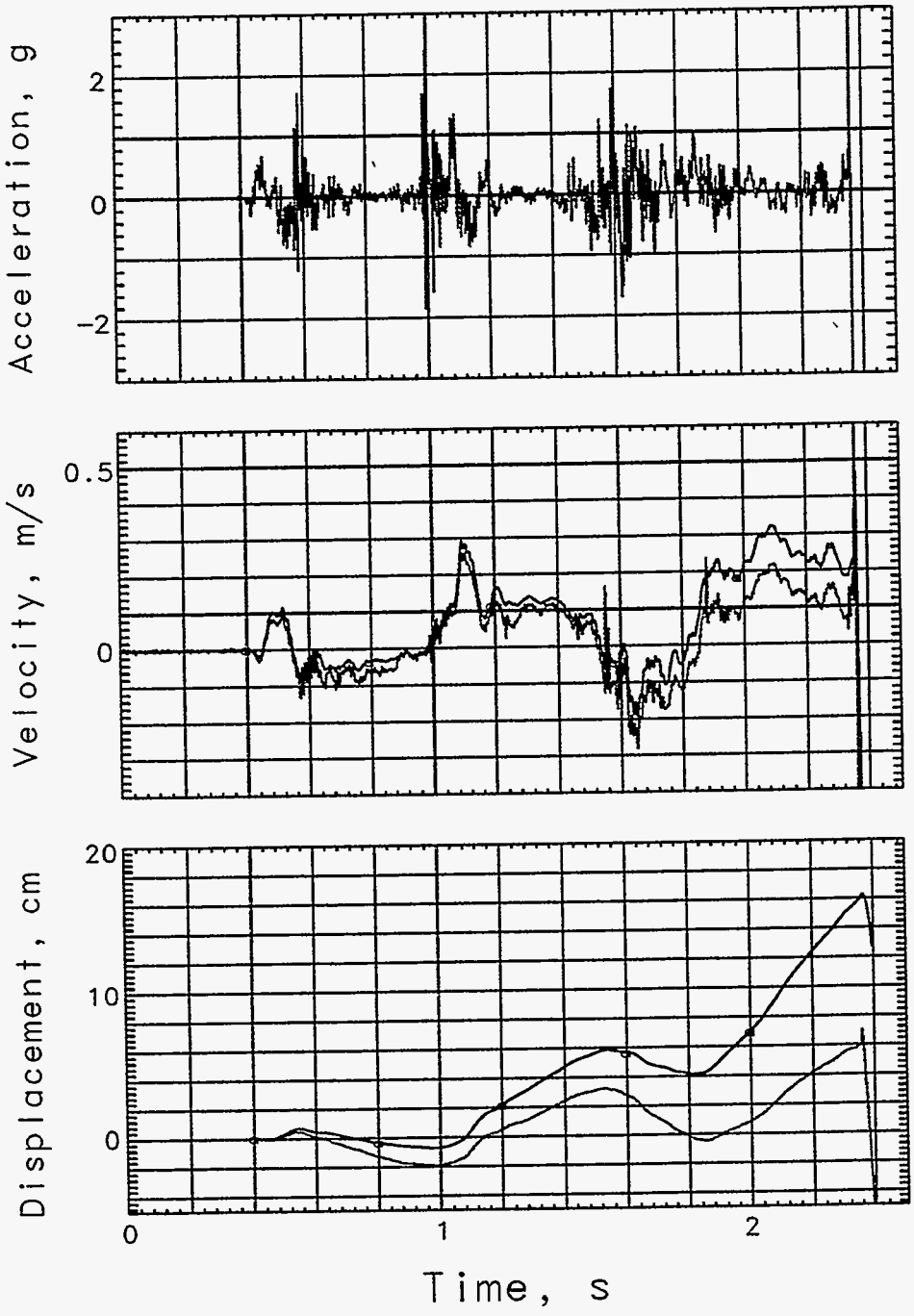


Figure 4.4 Explosion–induced horizontal–transverse motion of the recording trailer (station 71). Data records annotated with an 'a' are derived from the accelerometer. Station signals were interrupted at about 2.4 s after detonation.

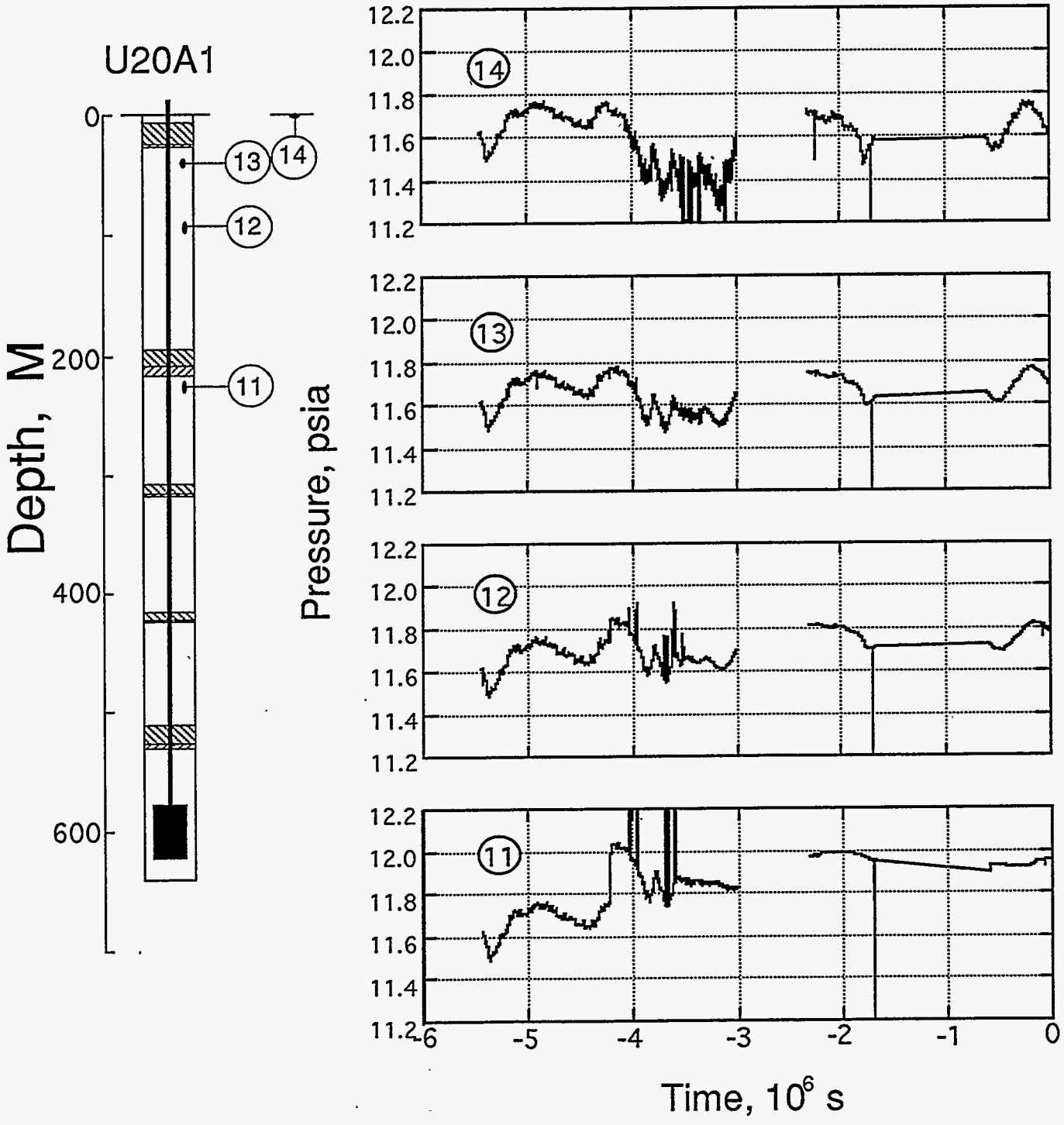


Figure 4.5 Permeability pressure data measured in hole U20ai prior to the event. Time is relative to the event.

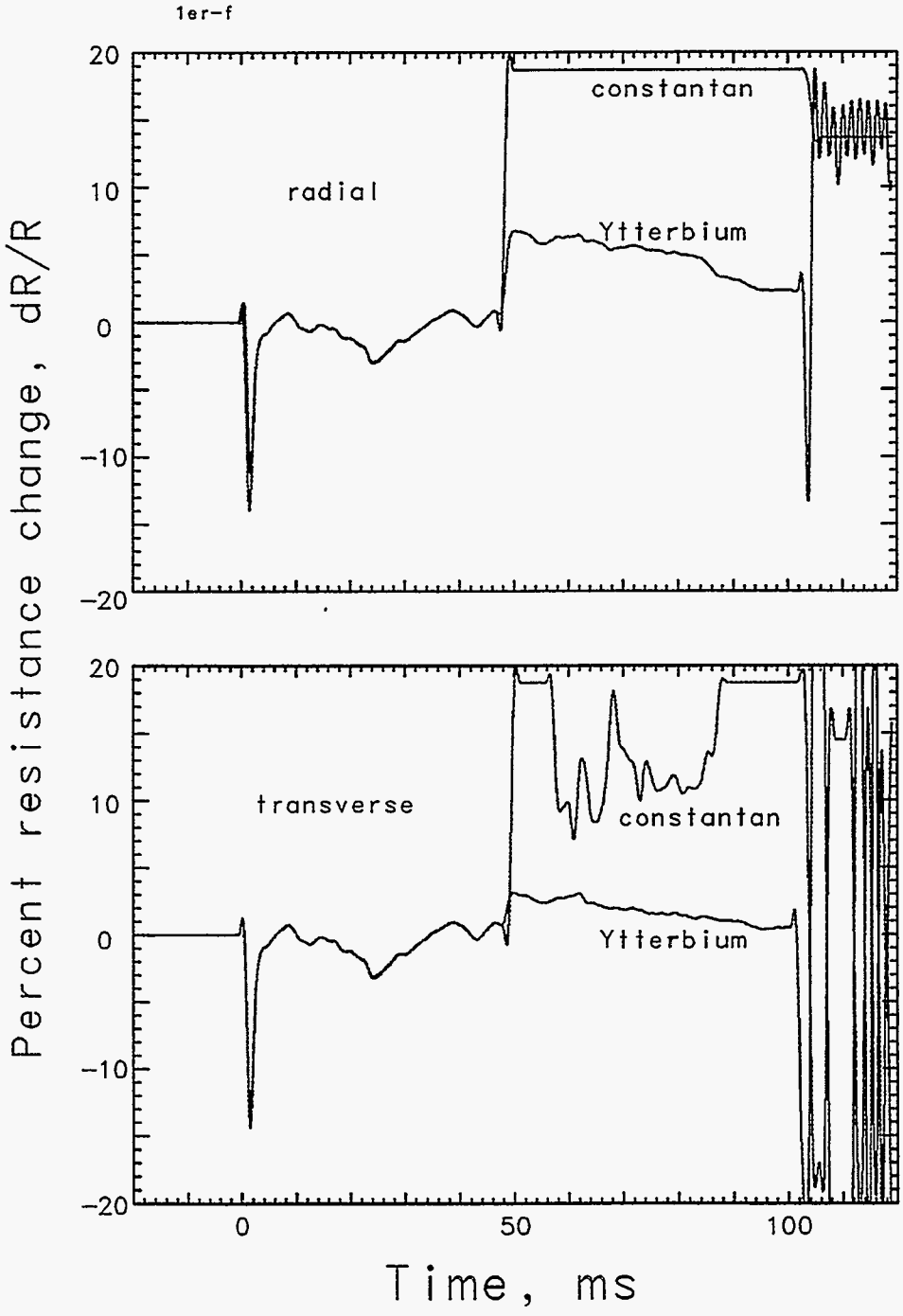


Figure 4.6 Output from the two element stress & strain transducers mounted to sense radial and transverse information at a range of 94.1 m from the working point (station 1). The signal prior to 48 ms is due to system excitation from the EMP. Both stress and strain signals are lost shortly after 0.1 s

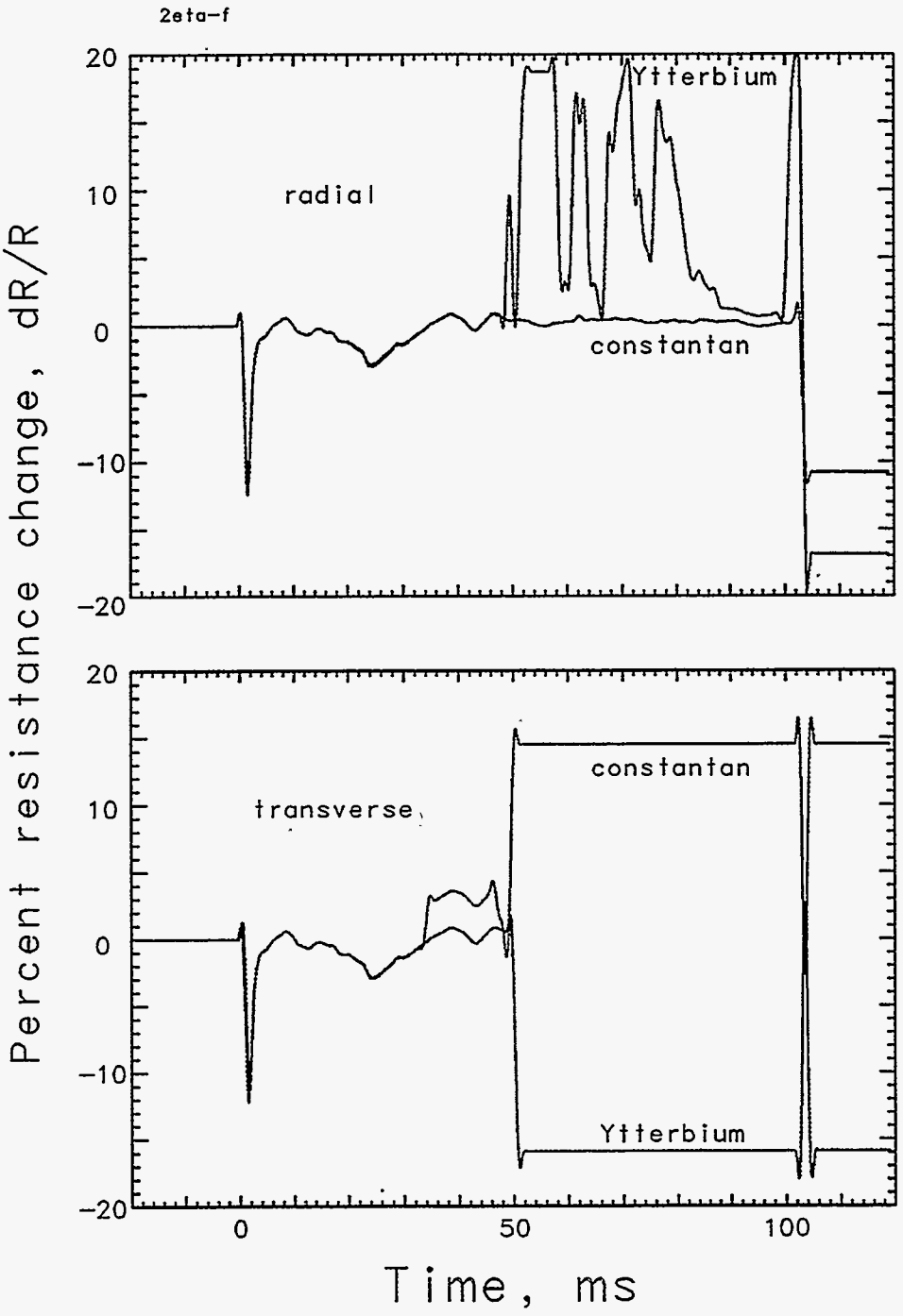


Figure 4.7 Output from the two element stress & strain transducers mounted to sense radial and transverse information at a range of 95.6 m from the working point (station 2). The signal prior to 48 ms is due to system excitation from the EMP. Both stress and strain signals are lost shortly after 0.1 s

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5. Richard A. Spilsbury, "Special Measurements Final Engineering Report for JEFFERSON, U20ai," EG&G, Energy Measurements, Las Vegas, NV, SM:86E–133–35, 13 May 1986.

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7. J. A. Kalinowski, "JEFFERSON Stress Gage Report", EG&G, Energy Measurements, Pleasanton, CA, JAK 92–12, April 14, 1992.

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