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HAZEBROOK

Containment Data Report

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Lawrence Livermore National Laboratory

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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

HAZEBROOK 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	yes	yes	yes
Cavity	yes	yes	yes
Atmospheric	yes	yes	yes
Motion			
Free field	no	-	-
Surface	yes	yes	yes
Plug	yes	yes	yes
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	no	-	-
Strain	no	-	-
Other Measurements [(c)]	no	-	-

(a) EXCOR/CORRTEX in emplacement hole.
(b) EXCOR measurement in emplacement hole.
(c) Motion of the recording trailer

Event Personnel

Containment Physics		Instrumentation	
B. Hudson	LLNL	C. Cordill	LLNL
E. Woodward	LLNL	M. Hatch	EG&G/AVO
J. Kalinowski	EG&G/AVO	L. Farthing	EG&G/NVO
T. Stubbs	EG&G/AVO	R. Spilsbury	EG&G/NVO

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1. Event Description

1.1 Containment summary

The HAZEBROOK event was detonated in hole U10bh of the Nevada Test Site (figure 1.1). Detonation time was 7:20 AM PST on February 3, 1987. No subsidence was observed. Radiation arrivals were detected to a depth of 122 m in the emplacement hole; however, no radiation was detected above ground. The HAZEBROOK event containment was satisfactory.

1.2 Site.

A magnified geologic map showing some of the surface features near the U10bh site is shown in Figure 1.2. The device had a burial depth of 186 m in Area 10 tuffs about 390 m above the static water level (SWL), as shown in the geologic cross sections of 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 is a schematic layout of the instrumentation in hole U10bh, designed to monitor the stemming emplacement procedures and performance on the HAZEBROOK event.

For quality assurance during emplacement, each of the four sanded gypsum concrete (SGC) plugs was monitored with arrays of thermistors and conductivity probes.

The coarse stemming below each of the four SGC plugs was instrumented with pressure and radiation stations. A pair of gauges was mounted to monitor the pressure challenging the bottom plug. Cavity pressure was monitored by two sets of three pressure transducers. One of the sets was mounted as an addendum to a gas sampling hose and the other was a stand–alone system. Each transducer consisted of a 10,000 psi rated gage connected to a water–filled, stainless steel tube extending from the gage (at a depth of about 145 m) to near the level of the working point. Both sets were pressurized with nitrogen to about 4000 psi at 1 second before detonation.

Sensitive pressure stations were also fielded below the top three plugs and in the ground surface 15.24 from Surface Ground Zero (SGZ) to study the permeability of the SGC plugs and geologic formation. These stations were monitored by Paroscientific® data acquisition systems that transmitted the data in digital form to be recorded on Waveteck 6000 instruments housed in an auxiliary recording facility (Van 8).

Vertical motion was monitored in the stemming at the three deepest standard pressure & radiation stations, in the bottom plug, and at 0.61 m depth in the ground surface, 15.24 m from SGZ. Triaxial motion of the recording trailer was also monitored.

Data from each of the transducers above (with the exception of the sensitive pressure stations) were transmitted to the recording trailer by an analog system and recorded on magnetic tape.

Hydrodynamic yield of the device and cavity subsidence was monitored by an EXCOR/CORRTEX cable (labeled "CLIPER/CORRTEX" in figure 1.5) fielded in the emplacement hole. Results of the hydrodynamic yield measurements are reported elsewhere[3].

A brief history of the fielding operations of the instrumentation (including the emplacement pipe strain measurements) is given in reference 4. Further details of the instrumentation are given in reference 5.

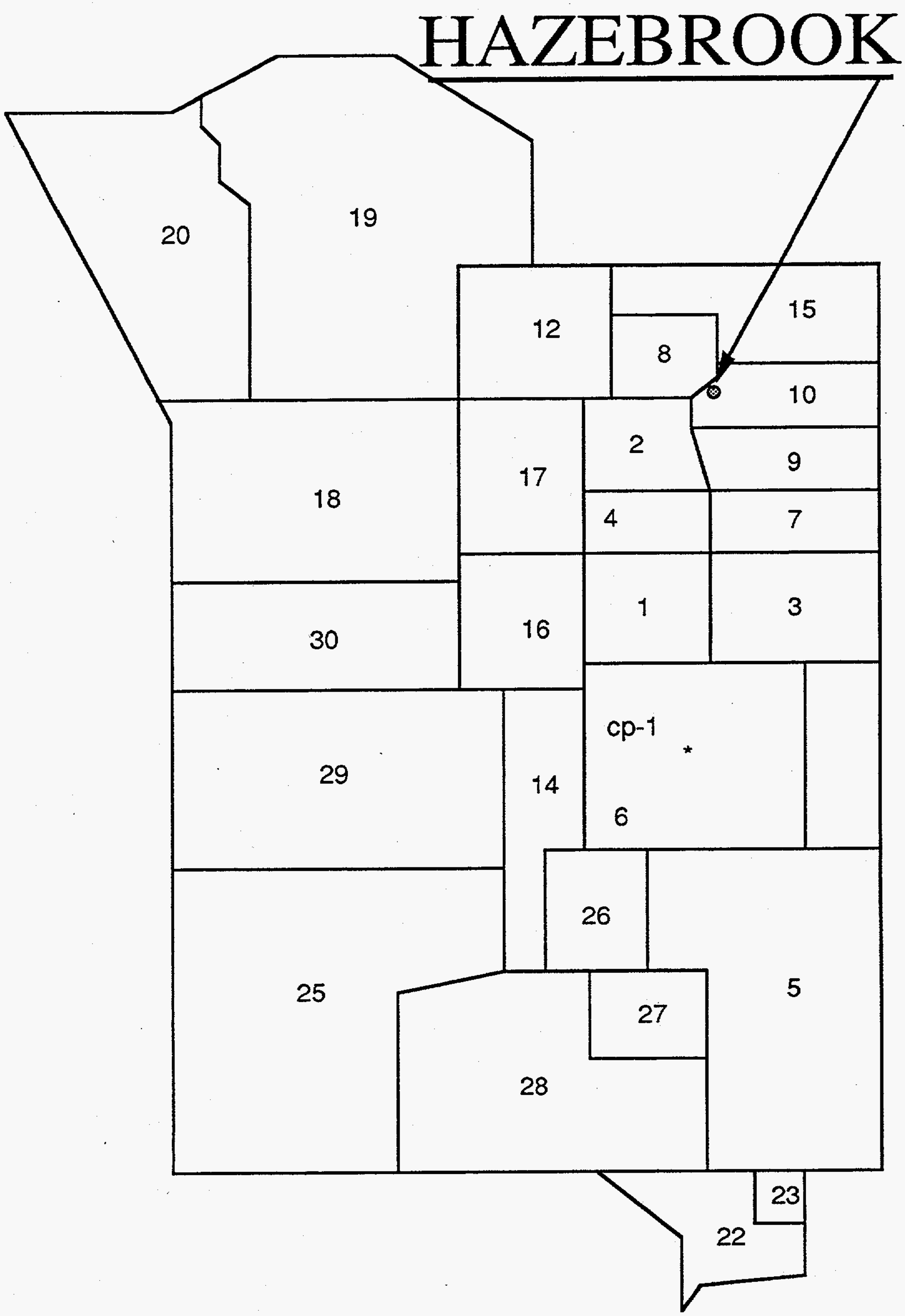


Figure 1.1 Map of the Nevada Test Site indicating the location of hole 10bh.

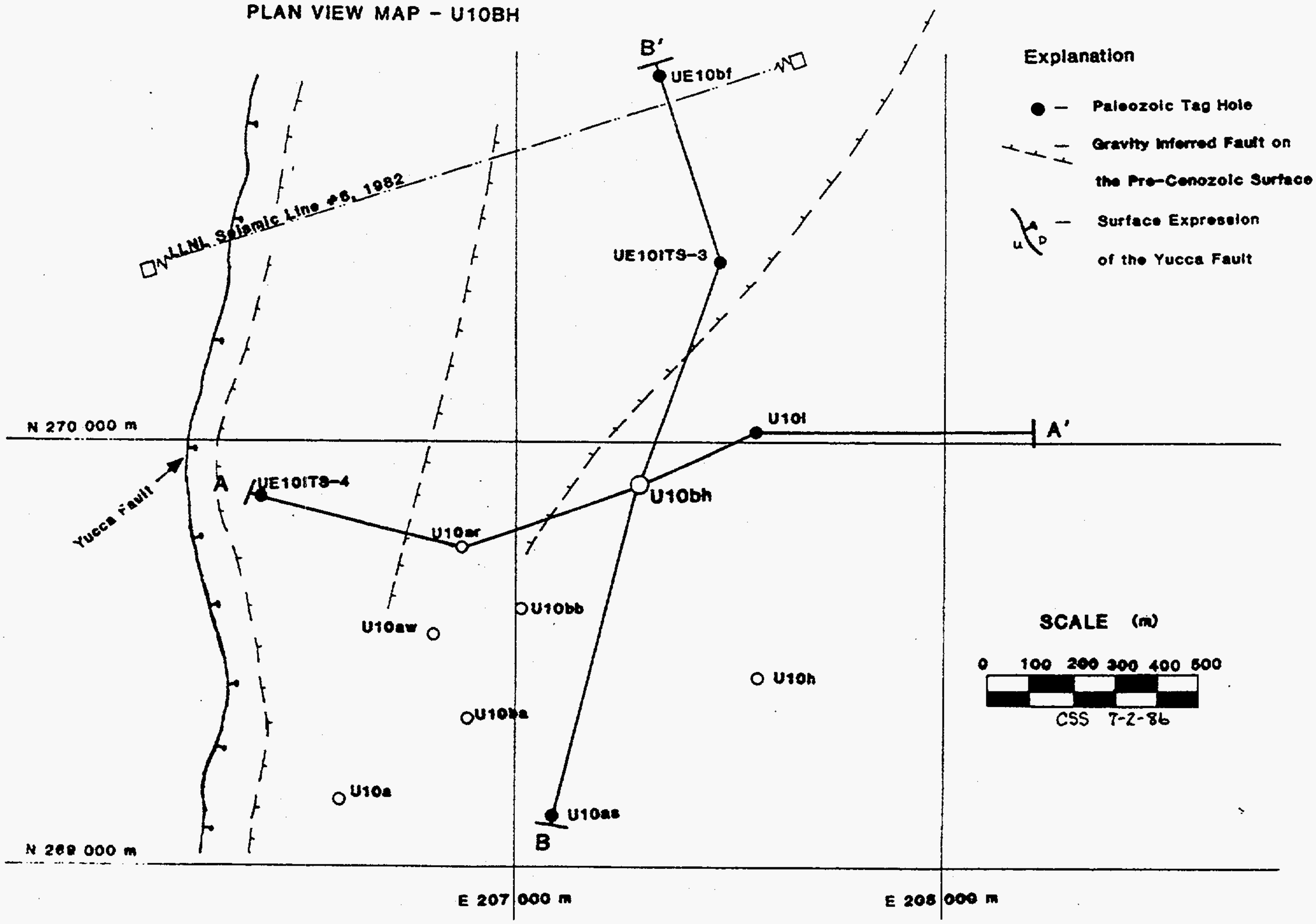
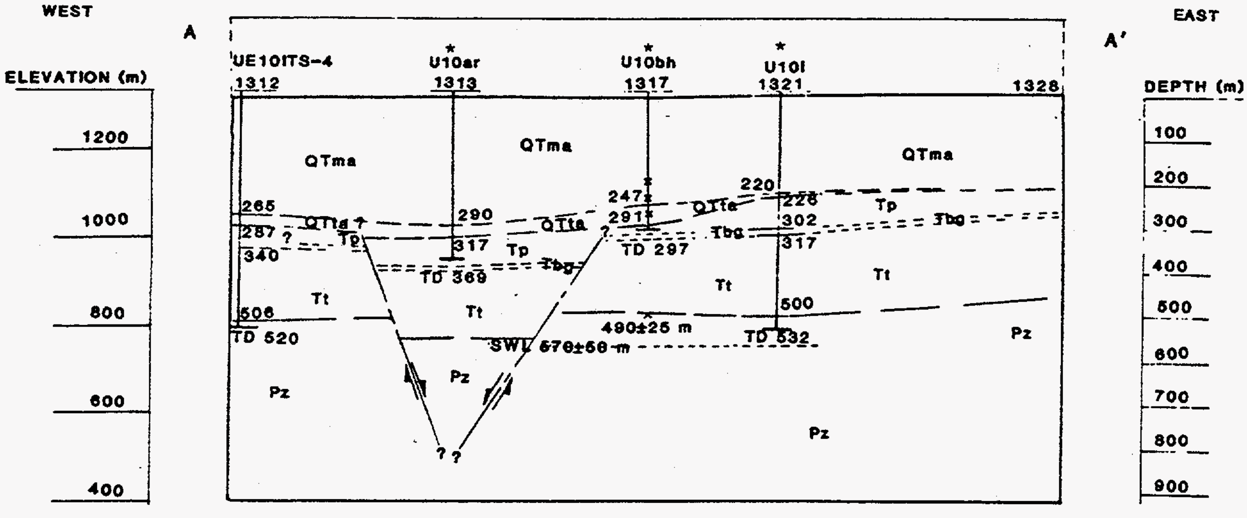


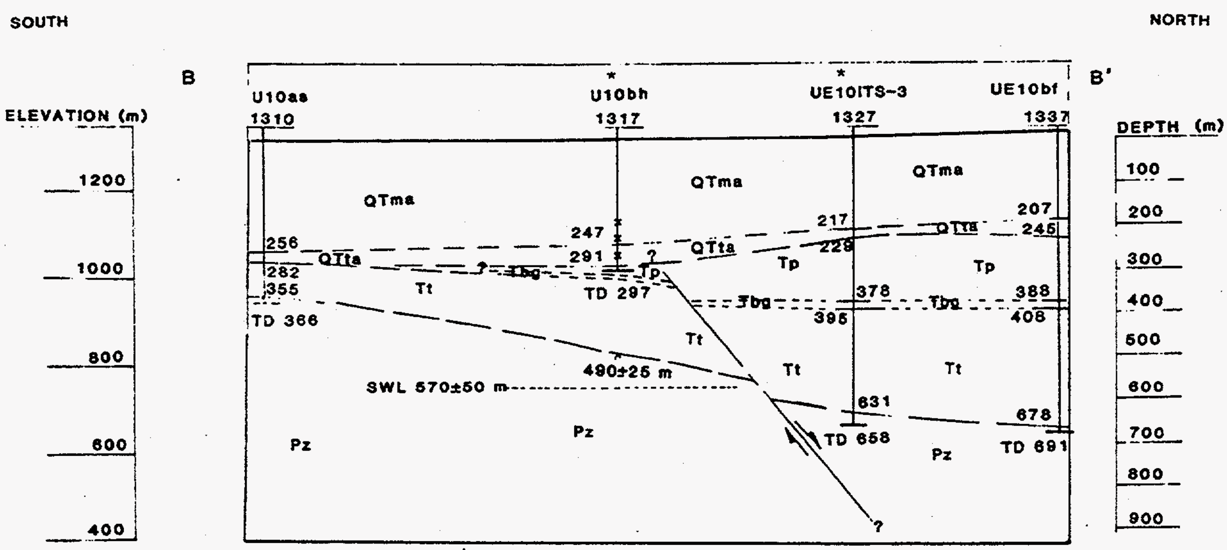
Figure 1.2 Geologic Map of the region near hole U10bh.



U10bh Geologic Cross Section A–A'

EXPLANATION

QTma	-	Mixed Alluvium
QTta	-	Basal Tuffaceous Alluvium
Tp	-	Paintbrush Tuff
Tbg	-	Grouse Canyon Airfall
Tt	-	Tunnel Beds and Older Tuffs
Pz	-	Paleozoic Rocks
SWL	-	Static Water Level
*	-	Bend in Section
? — — ?	-	Gravity Inferred Fault



U10bh Geologic Cross Section B–B'

Figure 1.3 Geologic cross section through hole U10bh.

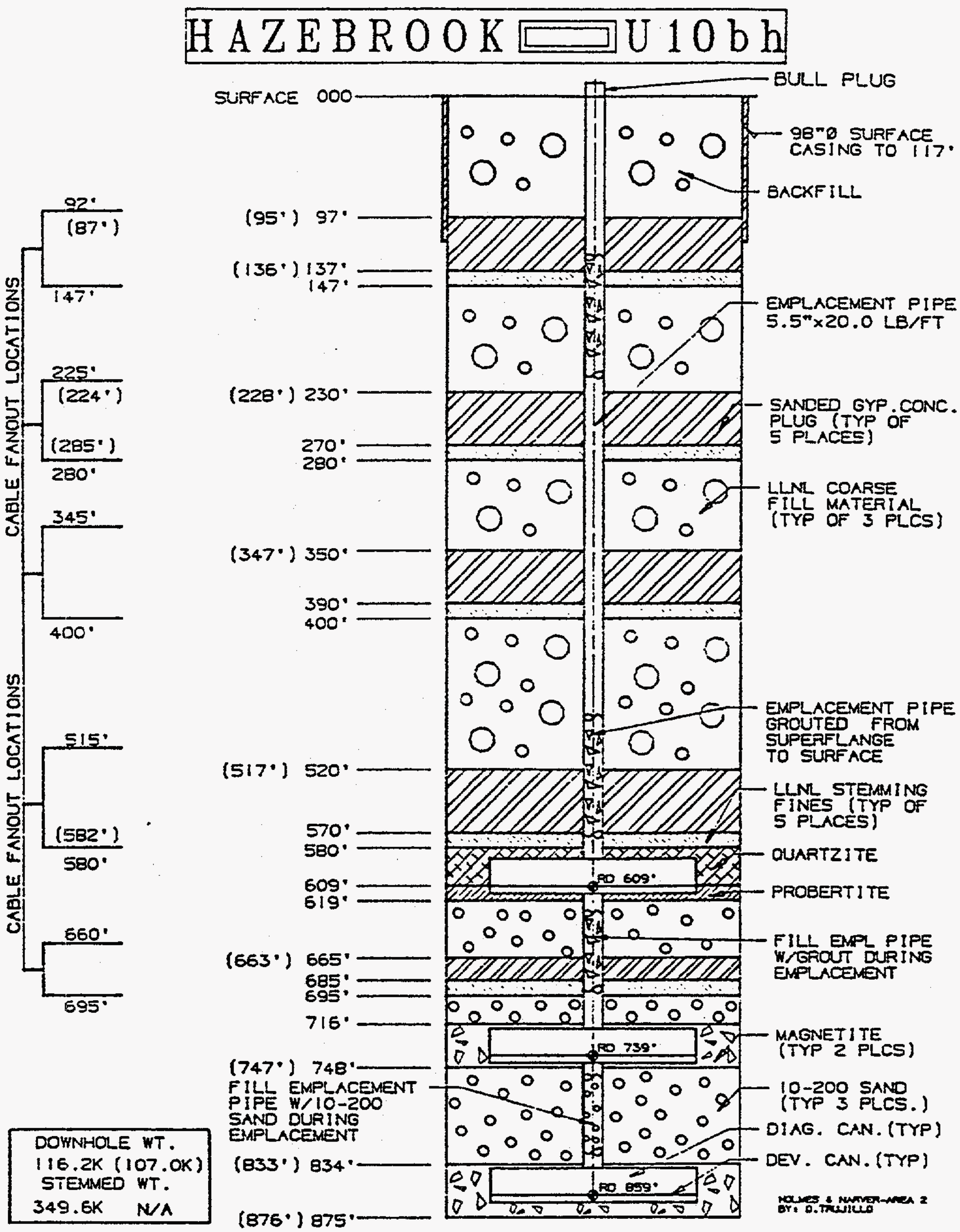


Figure 1.4 As-built stemming plan for hole U10bh.

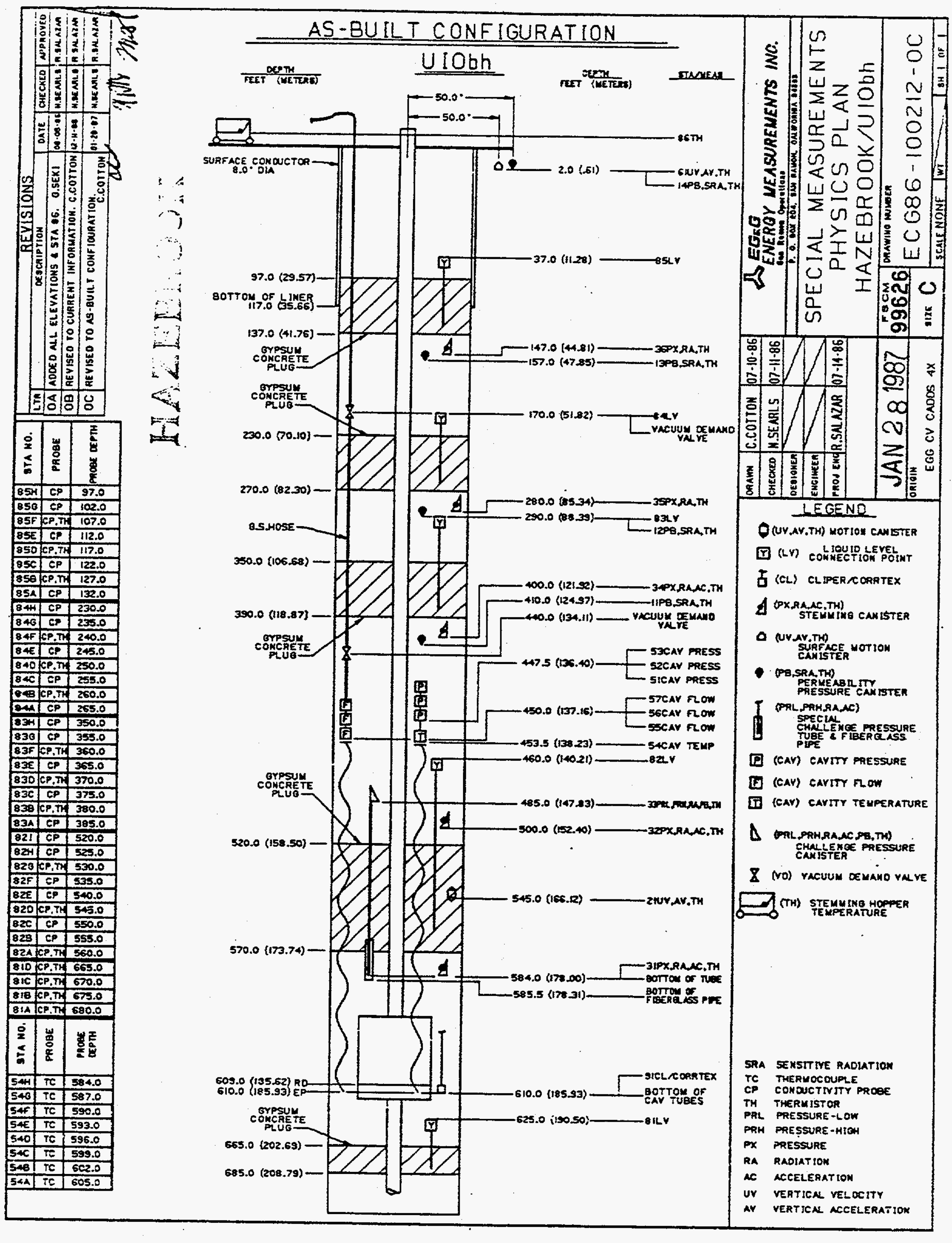


Figure 1.5 As-built containment instrumentation plan for the HAZEBROOK event emplacement hole U10bh.

2. Emplacement

2.1 Plug levels and temperature

Emplacement of each of the four SGC plugs was monitored with an array of conductivity probes and thermistors. The locations of the probes are tabulated in figure 1.5. Figures 2.1-2.4 show plots of the SGC emplacement and temperature histories. Open circles indicate the upper and lower boundary positions of the plugs as measured with tag lines while solid circles indicate the positions of the probe stations and the times at which the conductivity probes were activated. Those probes which included temperature sensors are noted in each figure caption. All plugs were emplaced as planned.

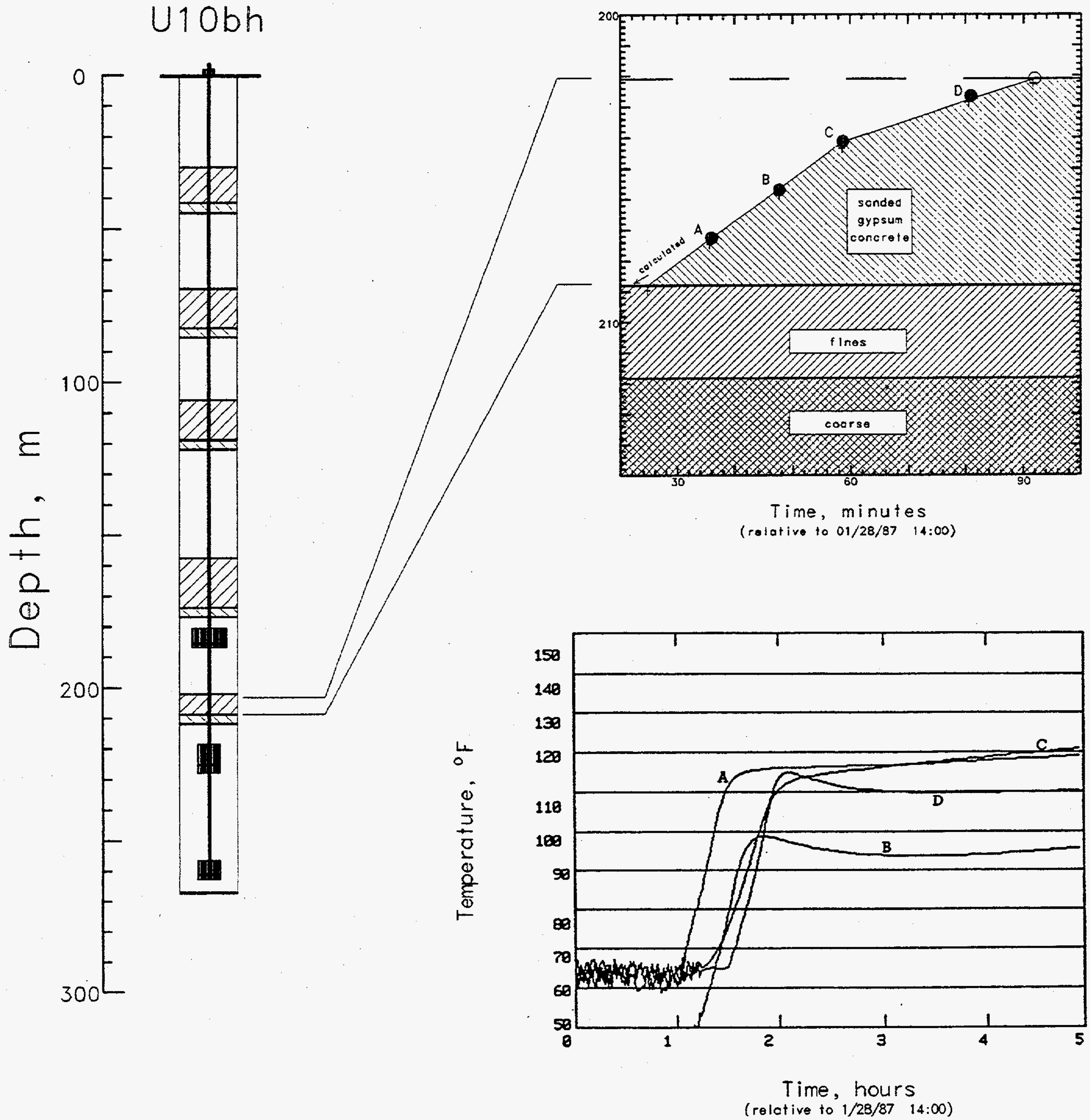


Figure 2.1 Sanded gypsum emplacement for plug #1. The upper and lower plug boundaries were calculated or determined with a tag line (open circle). Solid symbols indicate the probe elevations. All probes included temperature sensors.

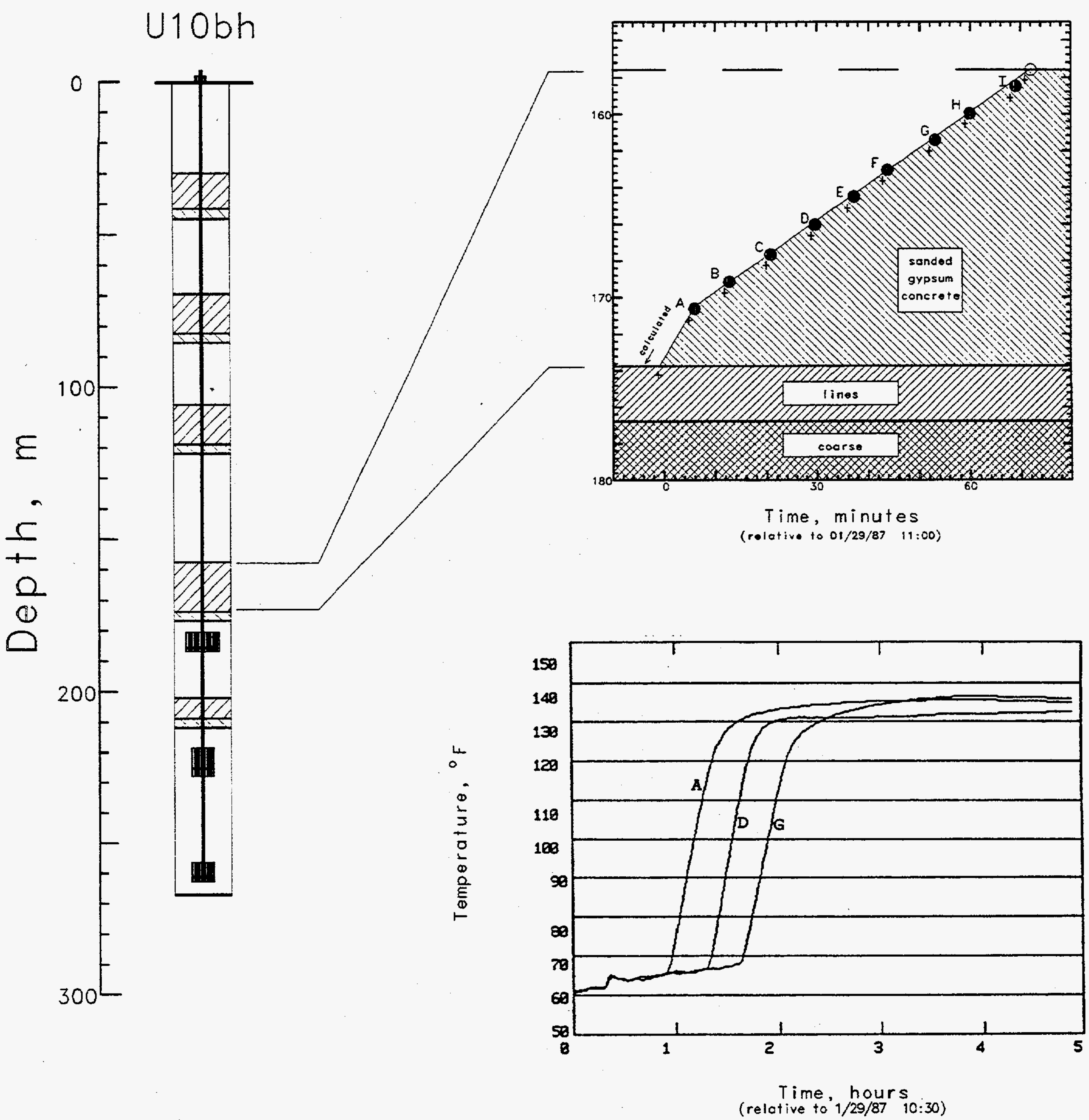


Figure 2.2 Sanded gypsum emplacement for plug #2. The upper and lower plug boundaries were calculated or determined with a tag line (open circle). Solid symbols indicate the probe elevations. Probes labeled A, D, and G included temperature sensors.

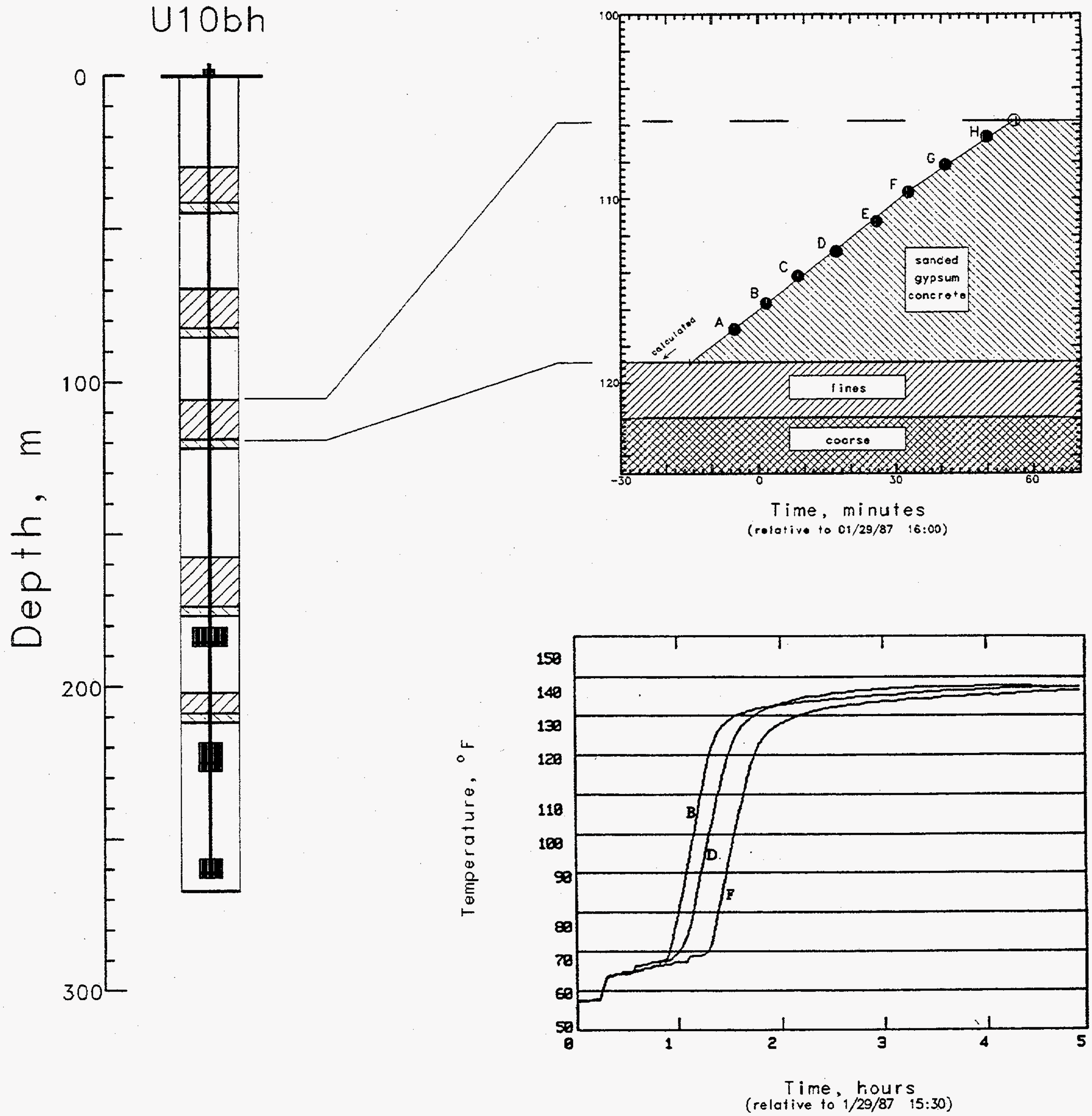


Figure 2.3 Sanded gypsum emplacement for plug #3. The upper and lower plug boundaries were calculated or determined with a tag line (open circle). Solid symbols indicate the probe elevations. Probes labeled B, D, and F included temperature sensors.

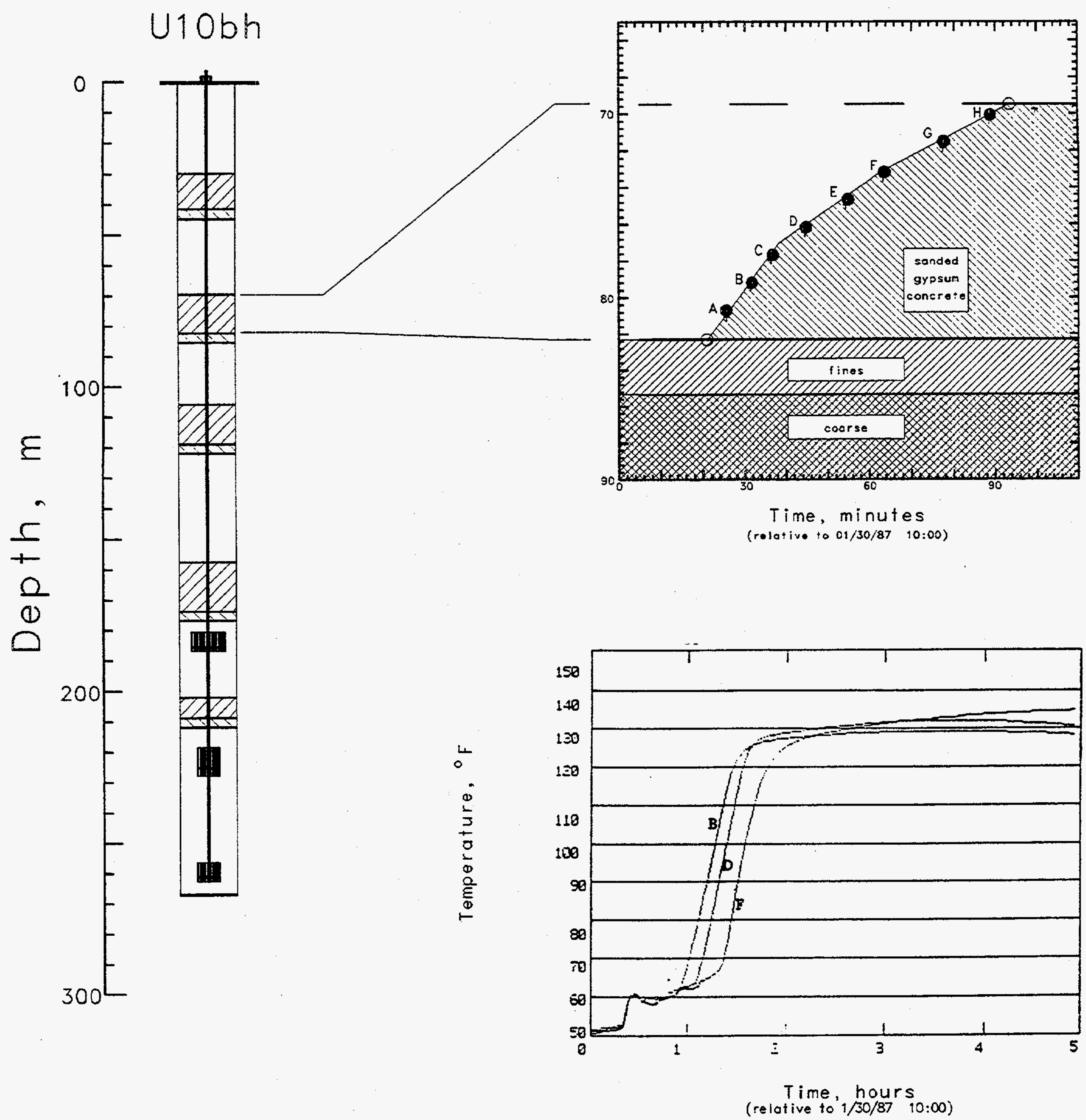


Figure 2.4 Sanded gypsum emplacement for plug #4. The upper and lower plug boundaries were determined with a tag line (open circles). Solid symbols indicate the probe elevations. Probes labeled B, D, and F included temperature sensors.

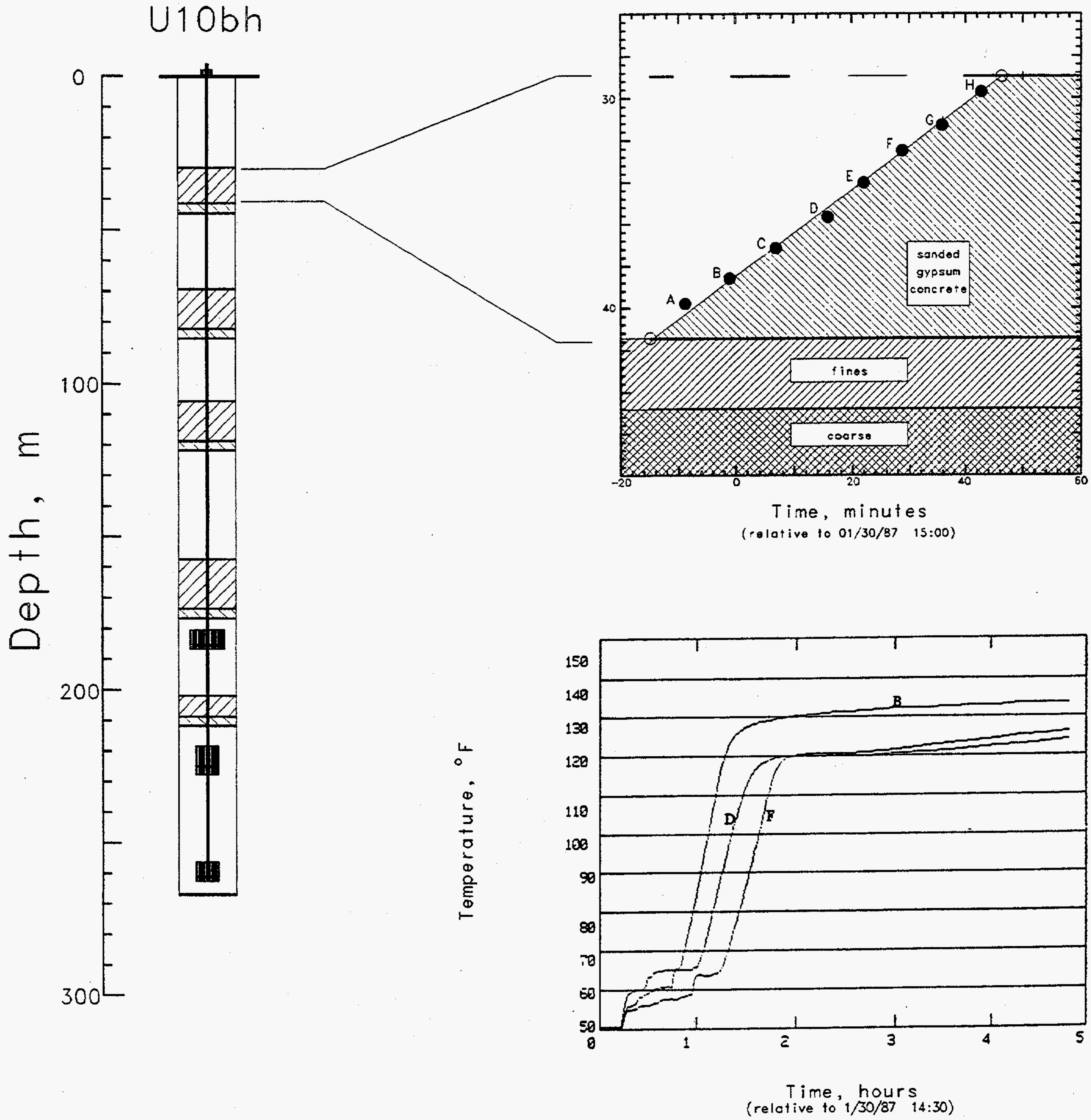


Figure 2.5 Sanded gypsum emplacement for plug #5. The upper and lower plug boundaries were determined with a tag line (open circles). Solid symbols indicate the probe elevations. Probes labeled B, D, and F included temperature sensors.

3. Stemming Performance

3.1 Radiation and Pressure

All pressure and radiation data are consistent with satisfactory containment.

As indicated in Figure 1.4, the region below each of the four SGC plugs was monitored by pressure and radiation stations, as was the ground surface, 15.24 m from SGZ. Signals from these stations were transmitted to the recording trailer in analog form and recorded on magnetic tape.

Pressure and radiation histories, from a few seconds before detonation until recording termination or station failure, are displayed in Figures 3.1–3.6. Radiation was seen in the stemming between the device and the third plug , but no further up the hole. Arrival of radiation immediately above the second plug (just above the device) occurred at less than 30 seconds (figure 3.7) with a second surge of radiation propagating through the coarse stemming to the third plug. This second wave of radiation arrived at station 32 at around 2500 seconds and at station 34 about 3000 seconds later.

The lack of any indication of early–time radiation at station 34 and the delayed arrival of the second pulse at both station 33 and 34 (figures 3.2, 3.3, and 3.4) suggests that two different propagation paths were involved. Figure 3.7 shows the early–time pressure on either side of the second plug. A peak difference of about 60 psi, occurring nearly 130 seconds after detonation, challenged this plug. The wave form of the radiation in the coarse stemming above this plug (station 32) and that of the radiation measured in the hose through which the challenge pressure was sensed (station 33) are also compared in figure 3.7. Except for times of less than 50 seconds and between 220 and 300 seconds, these wave forms are parallel indicating that the source of radiation for these two is the same. The difference in character of the two wave forms suggests that this early-time source was the radioactive gas in the hose leading to station 33. The delay of the second (late-time) pulse of radiation and its presence at station 34 suggests that its source was flow through or around the second plug.

Two sets of three transducers were fielded to monitor the gas pressure in the explosion–produced cavity. Each transducer consisted of a 10,000 psi rated pressure gage monitoring a water–filled stainless steel tube extending from the pressure gage to the region of the detonation. The tube had an outer diameter of 6.35 mm and an inner diameter of 3.17 mm. It was filled with water to inhibit shock closure and wound in a helix having a radius of about 5 cm and a pitch which approximated the inverse of the expected explosion–produced ground displacement gradient to inhibit loss from ground shear. The tube was pressurized shortly prior to detonation to about 4000 psi with dry nitrogen from a 1.2 l reservoir. It was expected that the detonation would vaporize or melt off the end of the tube allowing the water to be expelled, at times long after the shock passage, by the high pressure gas.

One trio of gages (51, 52, and 53) was a stand–alone system and figures 3.8 and 3.9 show both the early time and late time pressure wave forms measured by these gages. The second trio of transducers (55,56, and 57) was fielded as a continuation of a Radio Chemistry gas sampling hose in an effort to provide a clear path for the extraction of gas for a yield determination. As shown in figures 3.10 and 3.11, these transducers did not work as planned. A series of nine temperature sensors was also fielded on this trio (station 54). None of these gages yielded useful information and they are not shown.

A set of four sensitive pressure stations (11, 12, 13, and 14) was fielded in the emplacement hole and on the ground surface, at a range 15.24 m from SGZ, to investigate the communication of atmospheric pressure with subsurface locations. The data were recorded in an auxiliary trailer (Van 8) which was activated about 35 hours after the shot. Locations of these stations are shown in figure 1.5 and the resulting data are shown in figure 3.12.

3.2 Motion

Vertical acceleration of the stemming was measured on both sides of the second plug and below the third plug (stations 31, 32 and 34) while station 21 monitored the vertical motion of the second plug . The ground surface, at a depth of 0.91 m and a horizontal range of 15.24 m from SGZ, was instrumented for vertical acceleration and velocity. Explosion–induced data derived from these stations are shown in figures 3.13–3.18. Characteristics of the motion and of the motion transducers are given in tables 3.1–3.3.

3.3 Collapse

A single reading from the EXCOR transducer indicated a cable break at a depth of 175 m (just below the bottom plug). This was recorded at 0.2 s after detonation: the break could have occurred at an earlier time since the EXCOR electronics were disabled until this time. No further breaks were noted in the EXCOR cable (nor in any of the other sensor cables) for as long as data were recorded. A slight disturbance was sensed in plug#2 (station 21, figure 3.14) at 3.763 hours. The level of this signal was too low to be integrated to any meaningful wave form.

Table 3.1 Summary of Motion

Gauge	Slant Range (m)	Arrival Time (ms)	Acceleration Peak (g)	Velocity Peak (m/s)	Displacement Peak (mm)	Displacement Resid. (mm)
31av	7.93	9.9	> 1 k	13.3	33	(a)
32av	33.53	13.8	71	7.0	150	-130
34av	64.01	20.4	2.75	0.15	22	-35
21av	19.81	4.5[b], 8.6	56	2.06	33	32[c]
21uv	-	-	-	2.00	32	27
61av	185.95	123	0.75, 1.5[d]	0.126	26	-57
61uv	-	-	-	0.107	22	-65

(a) Transducer destroyed at about 16 ms.
(b) Emplacement pipe–stemming interaction.
(c) Approximate.
(d) Slap-down peak.

Table 3.2 Accelerometer Characteristics

Gauge	Natural Frequency (Hz)	Damping Ratio	System Range (g's)
31av	> 2000	NA	1000
32av	> 2000	NA	25
34av	> 2000	NA	25
21av	600	0.65	50
61av	250	0.75	25

Table 3.3 Velocimeter Characteristics

Gauge	Natural Frequency (Hz)	Time to 0.5 Amplitude (s)	Calibration Temperature (^oC)	Operate Temperature (^oC)	System Range (m/s)
21uv	3.606	8.28	25.80	32.62	6
61uv	3.515	8.37	25.81	4.57	2

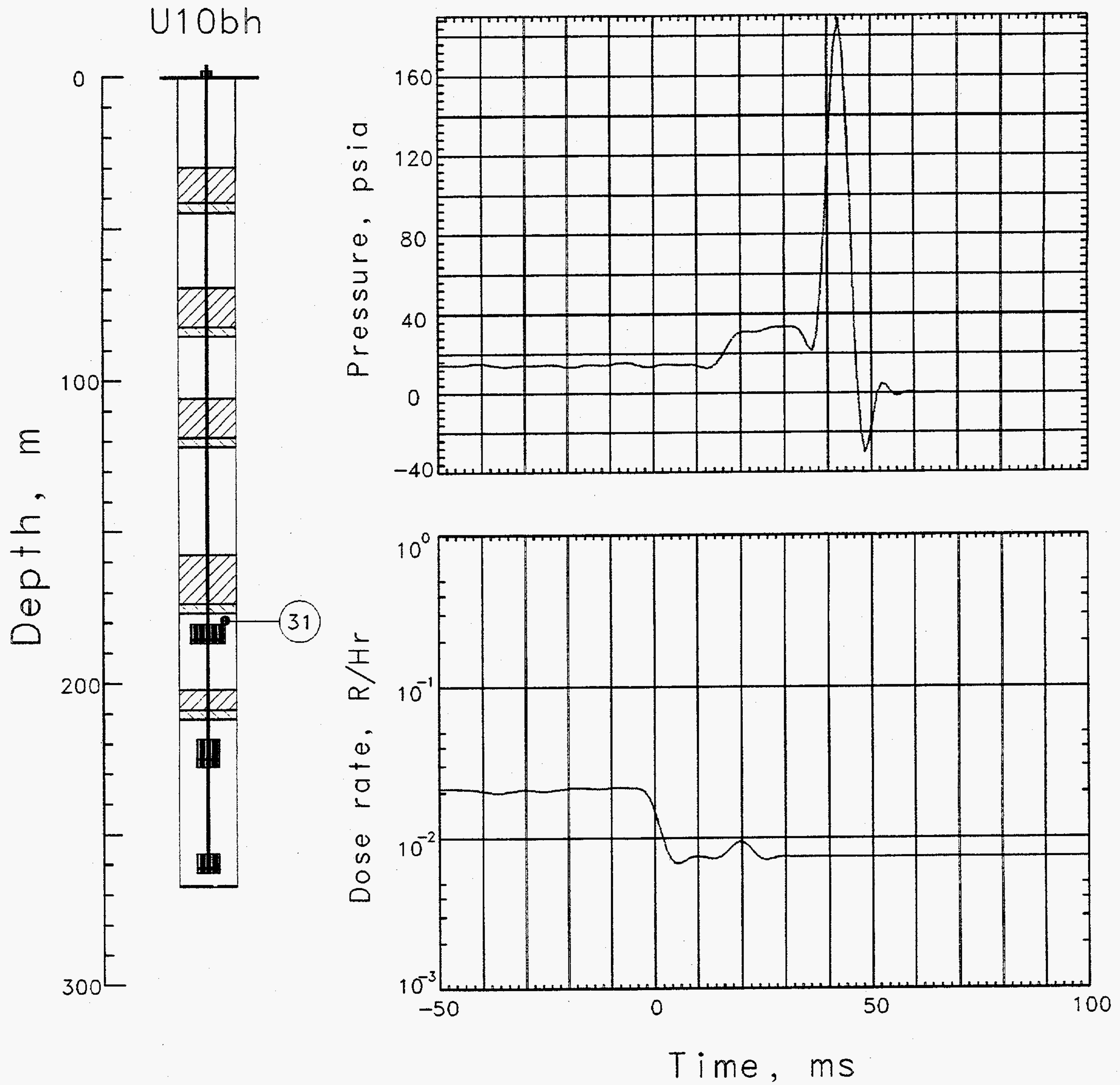


Figure 3.1 Pressure and radiation measured in the coarse stemming below SGC plug #2 (station 31 at 178 m depth). Station signals were lost shortly after detonation, presumably due to shock arrival.

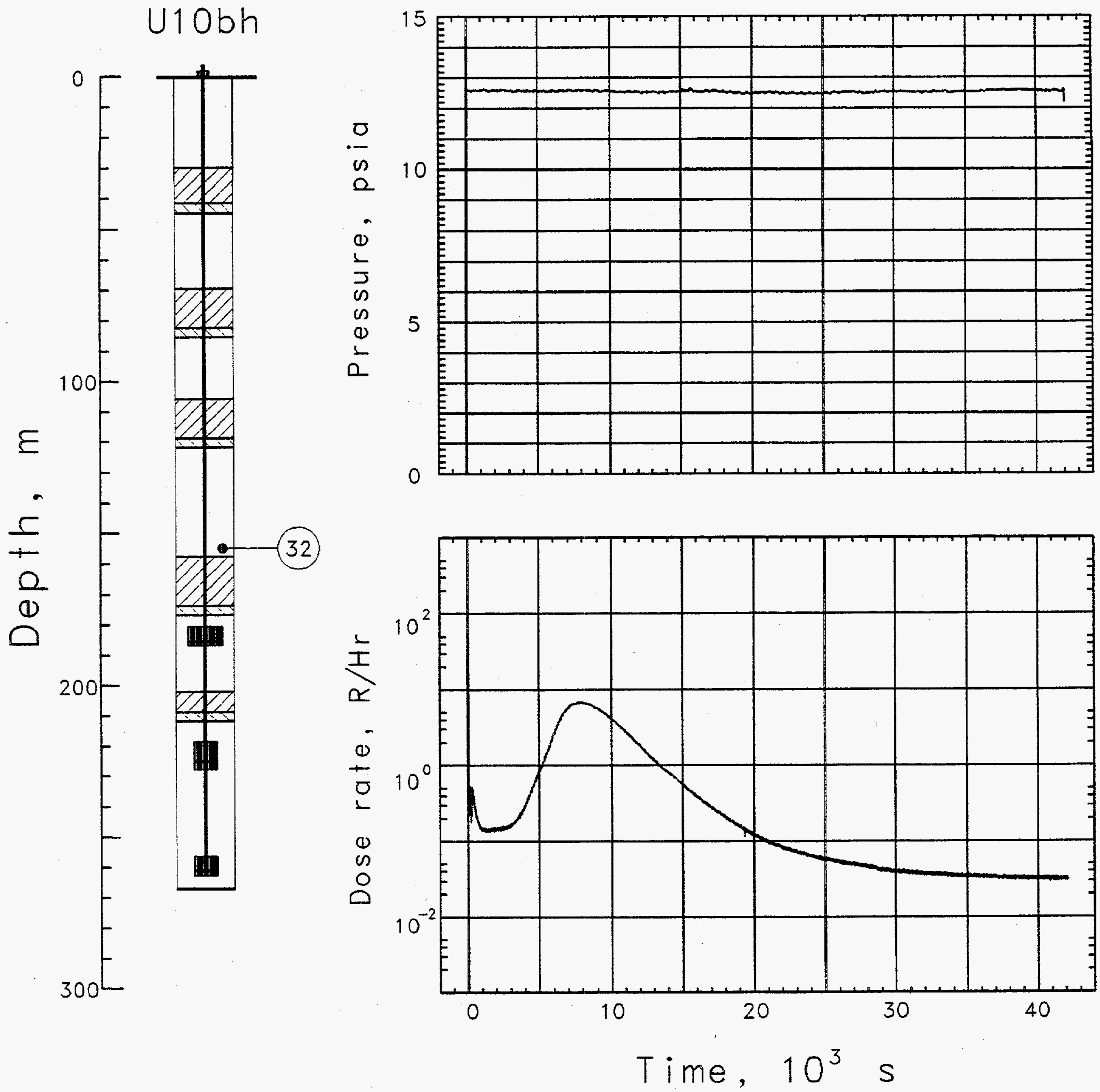


Figure 3.2 Pressure and radiation measured in the course stemming above SGC plug #2 (station 32 at 152 m depth). First arrival of radiation is about 22 s.

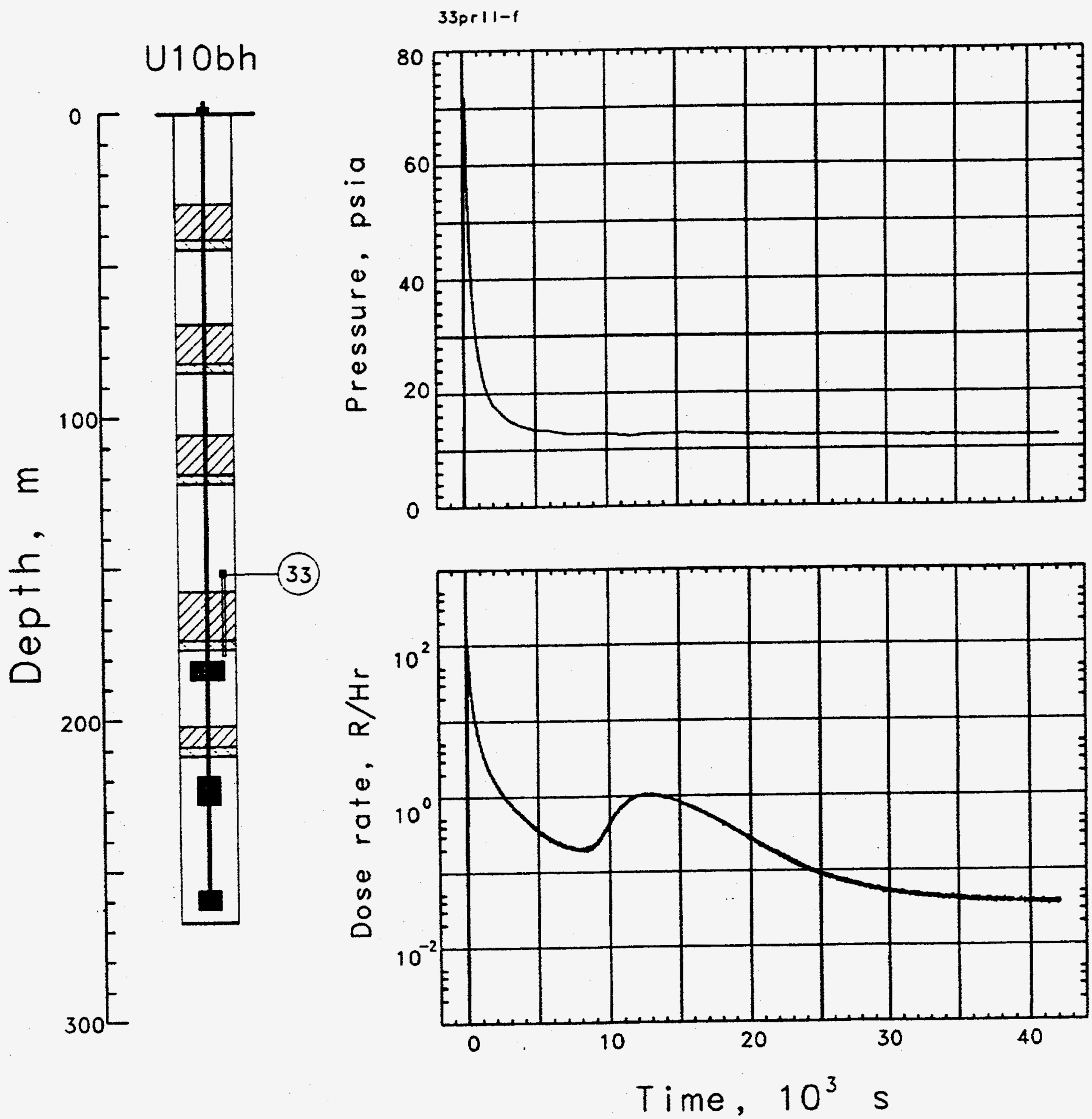


Figure 3.3 Pressure and radiation challenging the second plug as measured in the coarse stemming below it (station 33 at 148 m depth). Measurements were taken through a hose that penetrated the second plug and extended about 4 m below it to a depth of 178 m. First arrival of radiation is unknown, but probably before 25 s.

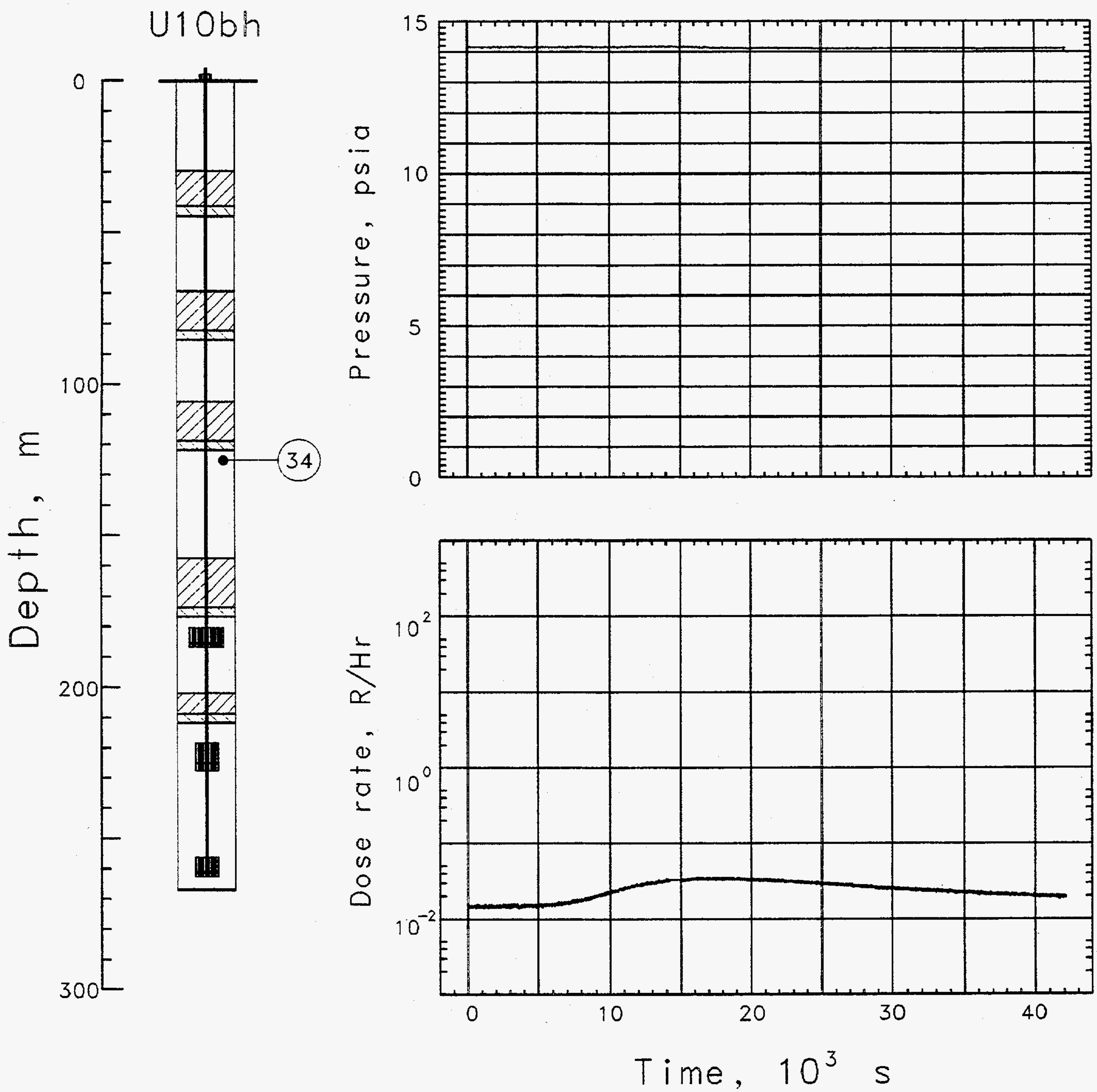


Figure 3.4 Pressure and radiation measured in the coarse stemming below SGC plug #3 (stations 34 at 122 m depth and 11 at 125 m depth). First arrival of radiation was at about 5000 s.

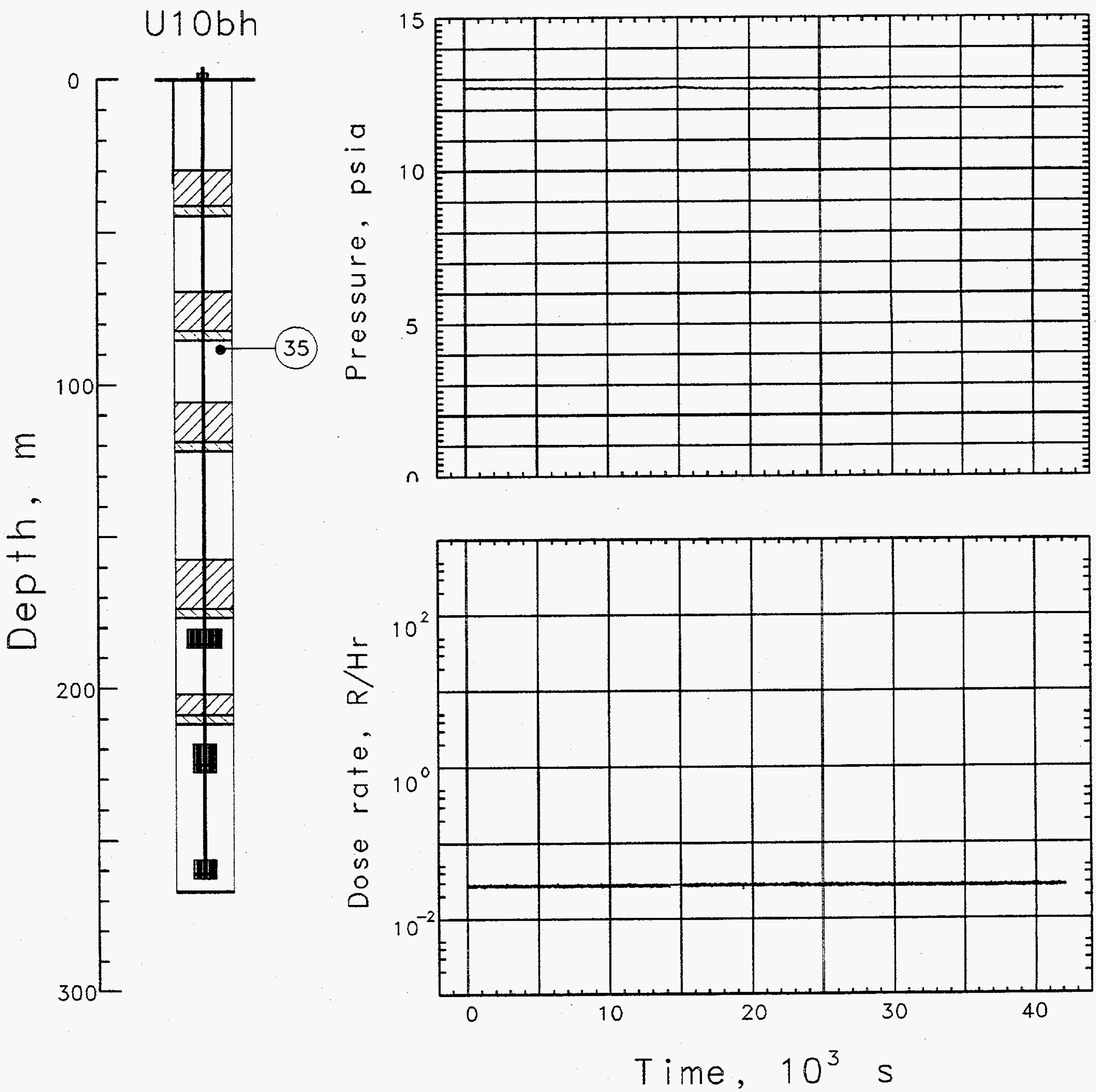


Figure 3.5 Pressure and radiation measured in the coarse stemming below SGC plug #4 (stations 35 at 85 m depth and 12 at 88 m depth).

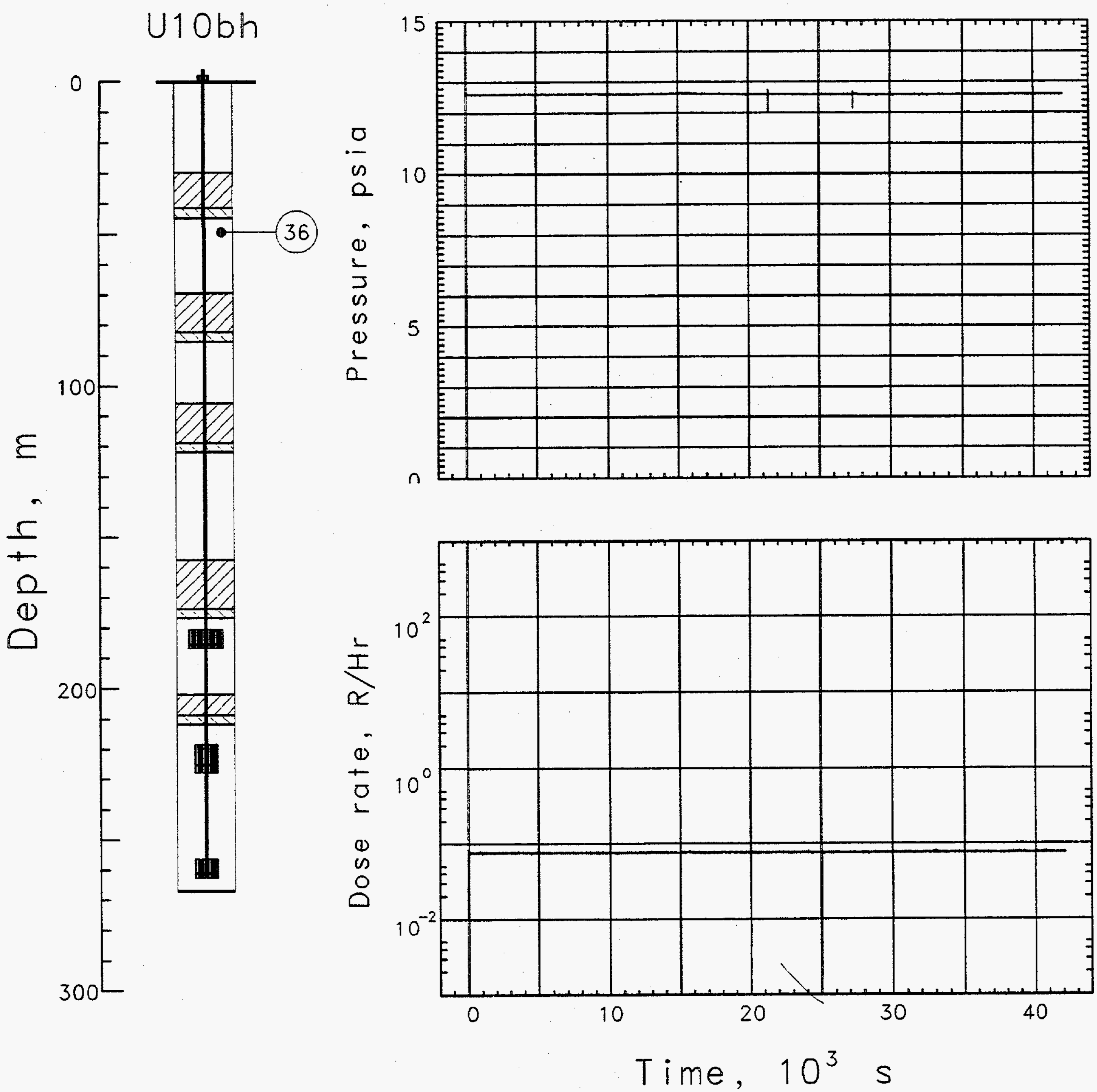


Figure 3.6 Pressure and radiation measured in the coarse stemming below SGC plug #5 (stations 36 at 45 m depth and 13 at 48 m depth).

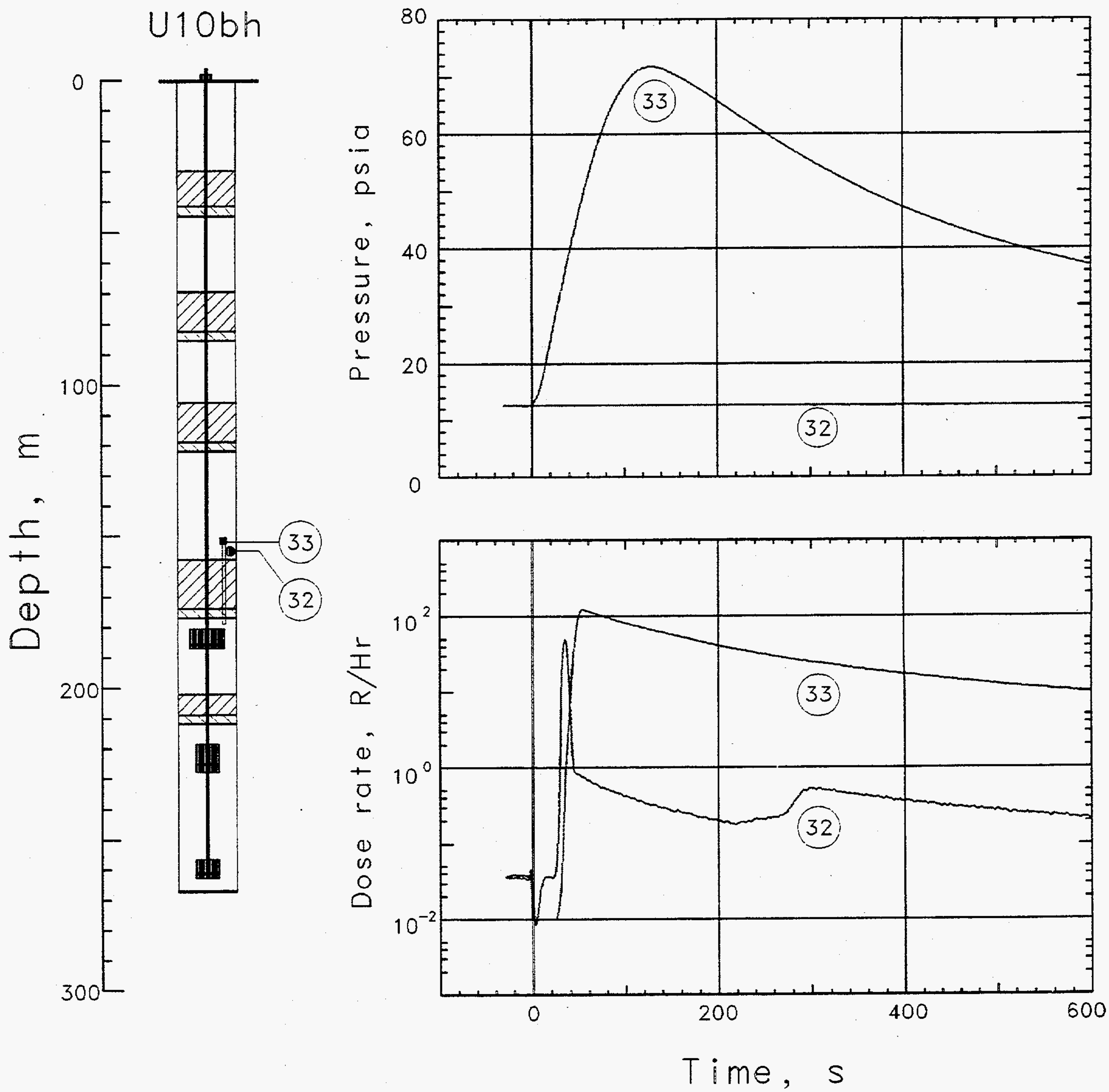


Figure 3.7 Comparison of pressures across the second plug and the radiation measured immediately above this plug. Pressure challenging the plug reached a peak of 60 psi at about 130 s. Radiation arrived at both stations at about 22 s.

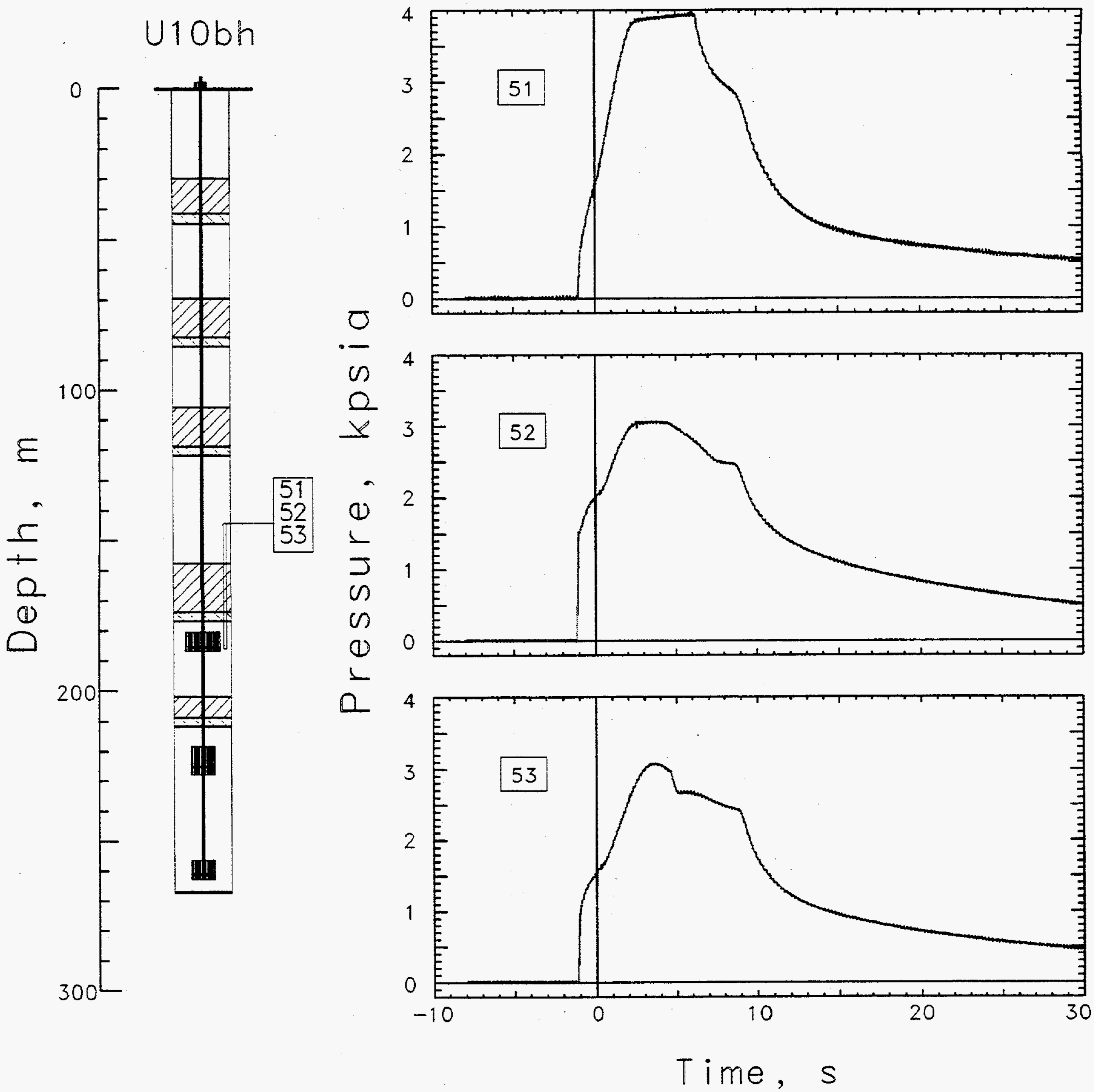


Figure 3.8 Early time wave forms of pressure measured through tubes extending from a depth of 145 m to near the W.P. A pressure of about 4000 psi from a 1.2 l reservoir of dry nitrogen was applied before shot time.

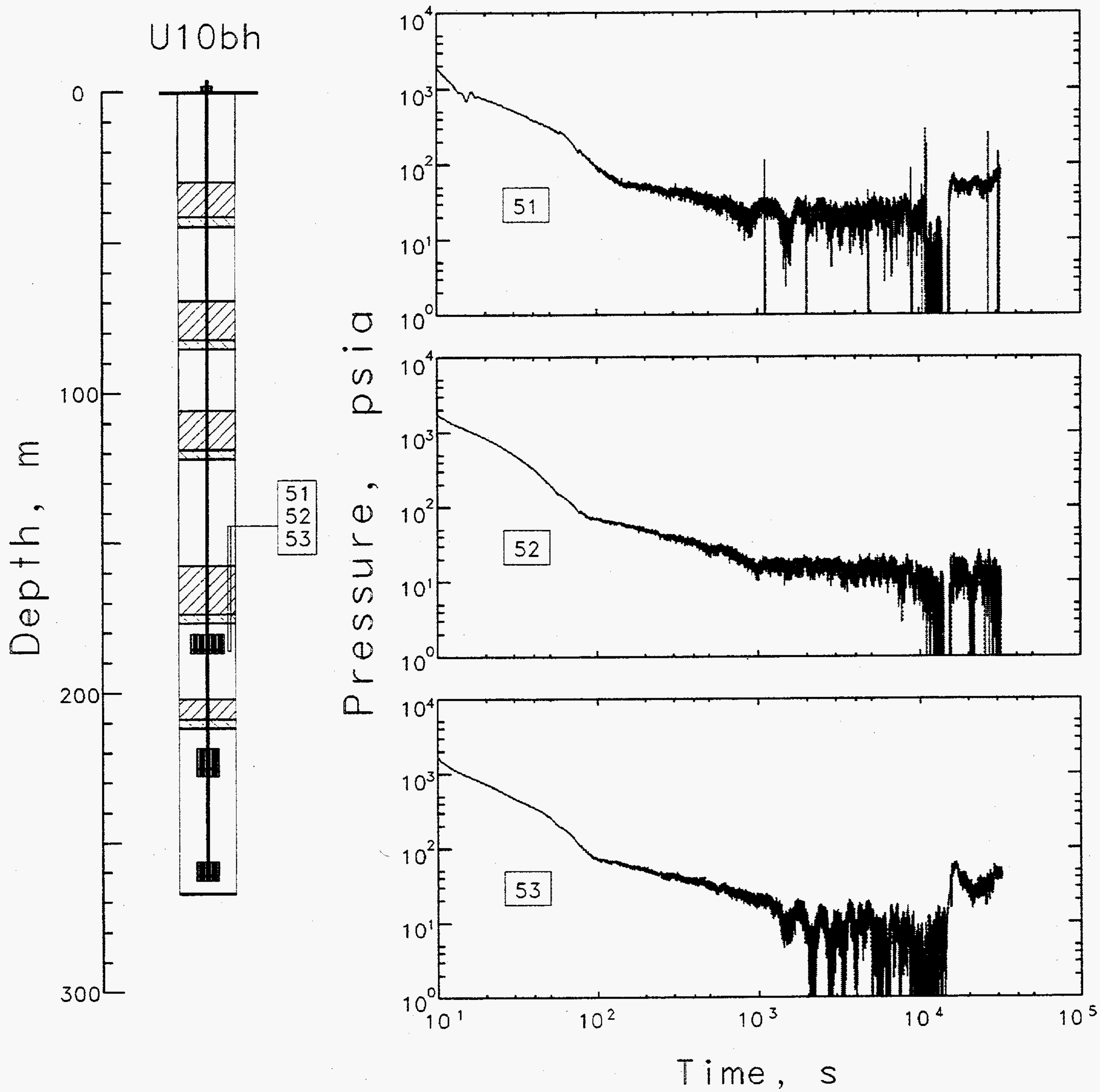


Figure 3.9 Late time wave forms of pressure measured through tubes extending from a depth of 145 m to near the W.P. A pressure of about 4000 psi from a 1.2 l reservoir of dry nitrogen was applied before shot time.

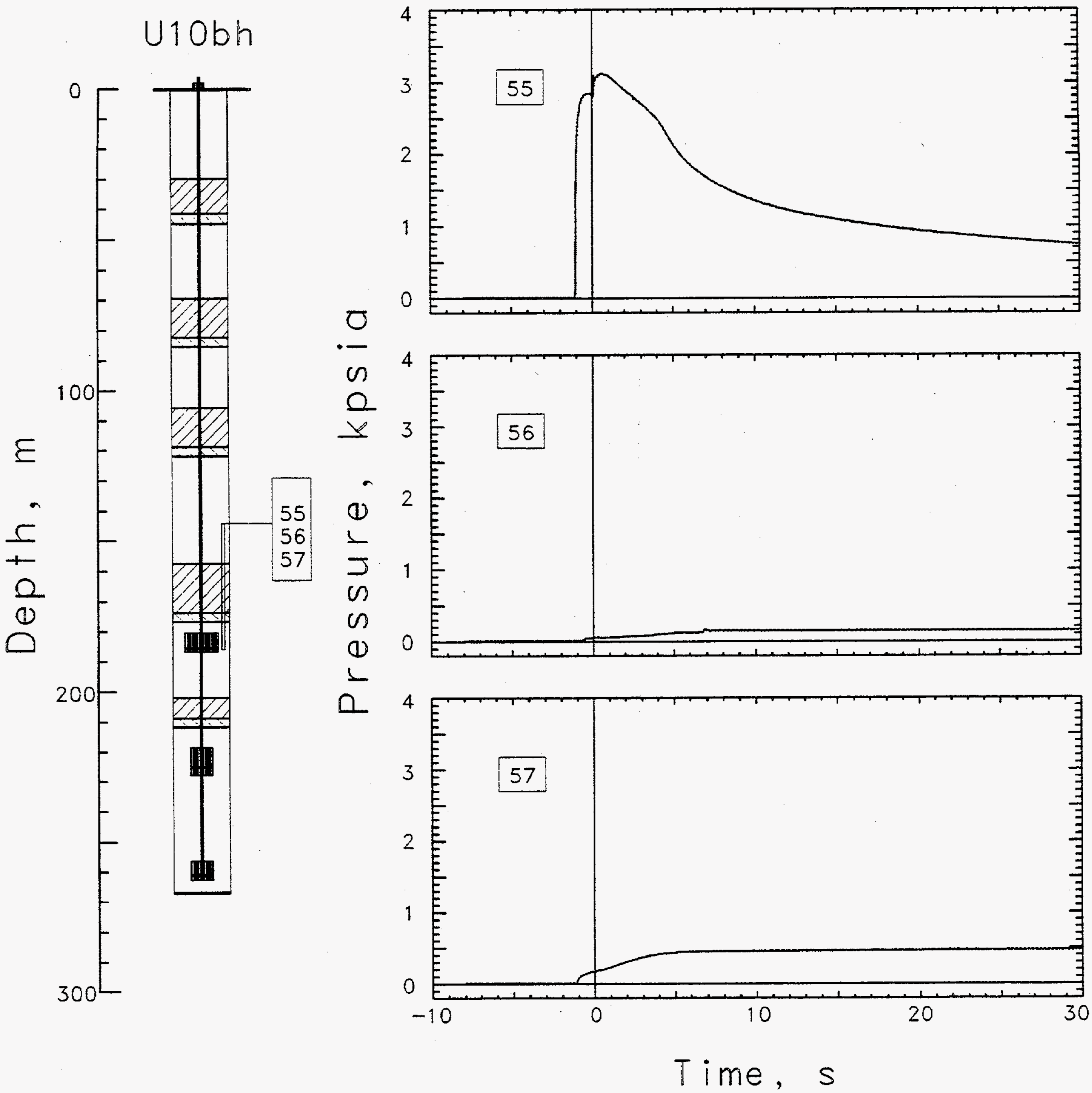


Figure 3.10 Early time wave forms of pressure measured through tubes extending from a depth of 145 m to near the W.P. A pressure of about 4000 psi from a 1.2 l reservoir of dry nitrogen was applied before shot time. These transducers were an extension of the gas sample system which extended upward to the radio chemistry trailer.

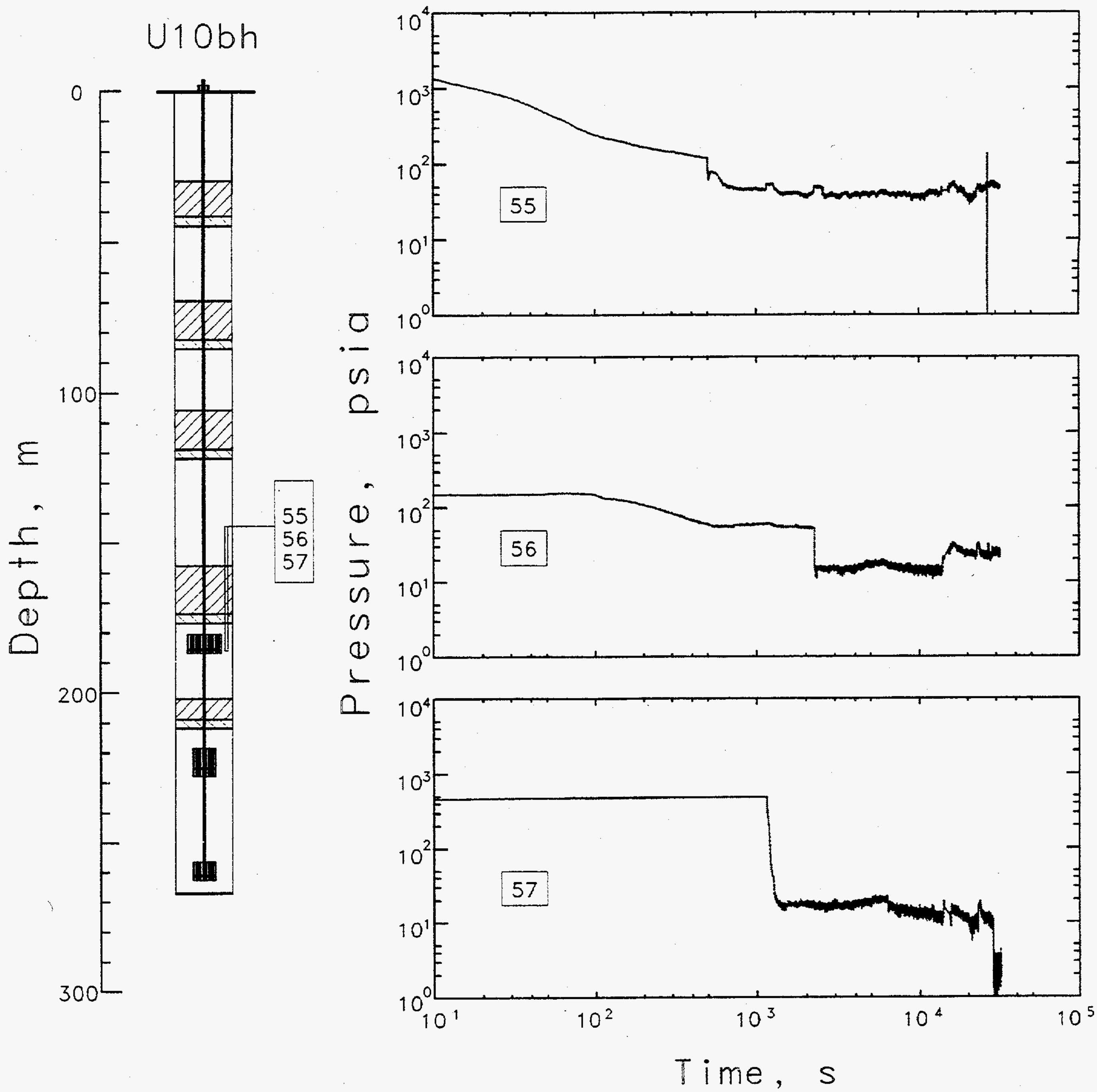


Figure 3.11 Late time wave forms of pressure measured through tubes extending from a depth of 145 m to near the W.P. A pressure of about 4000 psi from a 1.2 l reservoir of dry nitrogen was applied before shot time. These transducers were an extension of the gas sample system which extended upward to the radio chemistry trailer.

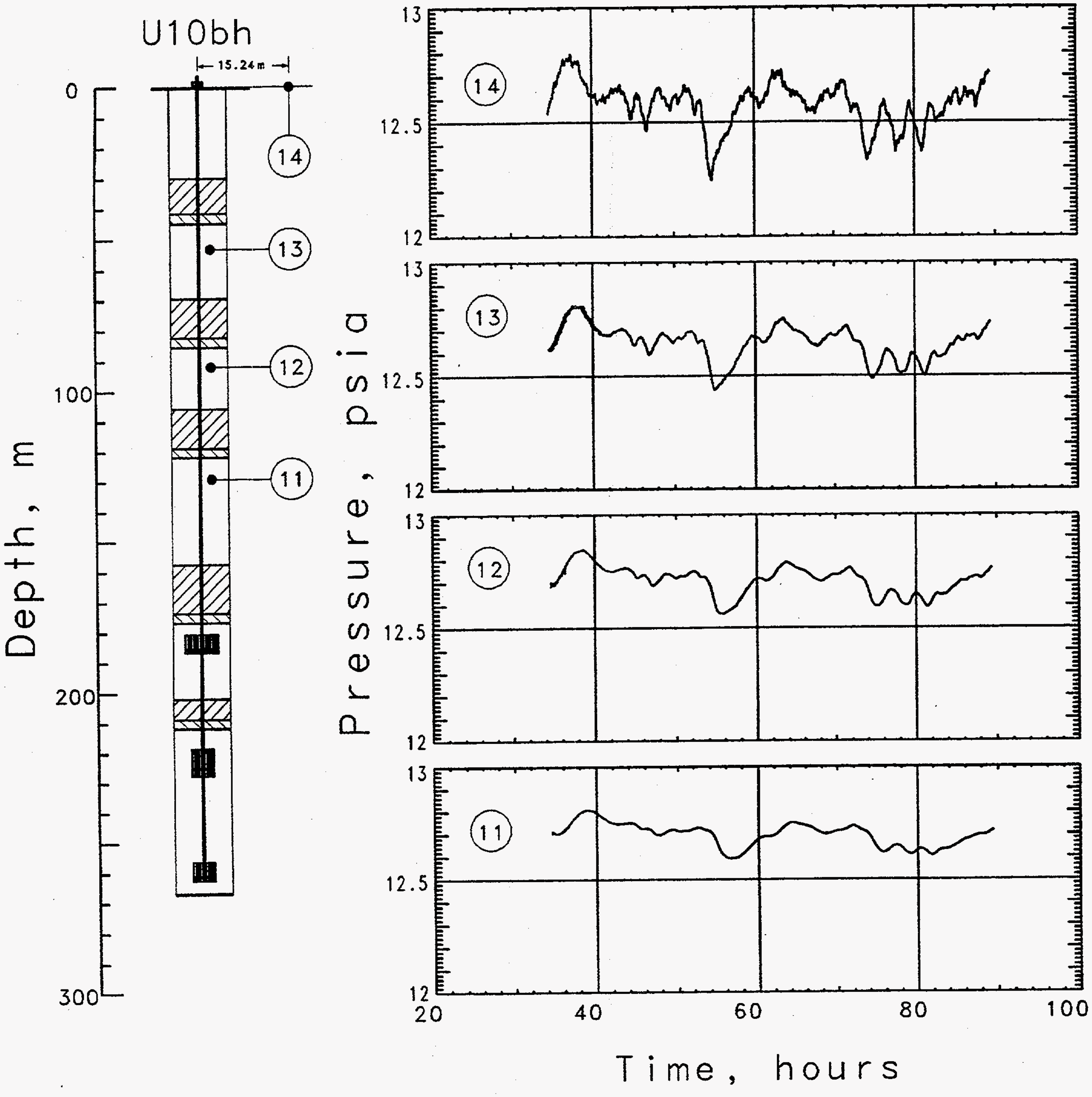


Figure 3.12 Pressures measured in the emplacement hole as a study of site permeability.

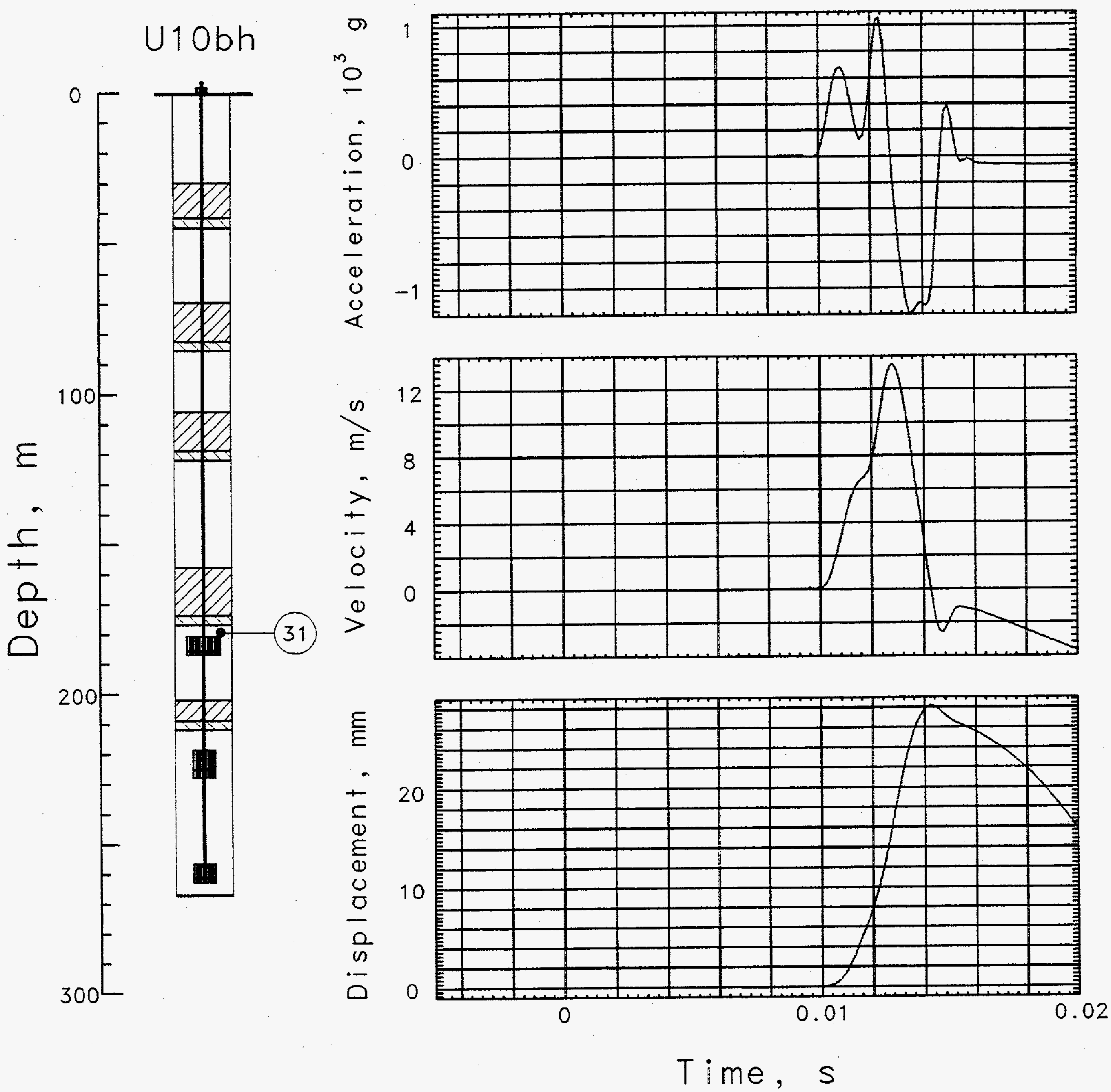


Figure 3.13 Explosion–induced vertical motion in the coarse stemming of the emplacement hole at a depth of 178 m (station 31, below plug #2)). The transducer was apparently damaged at about 0.016 s.

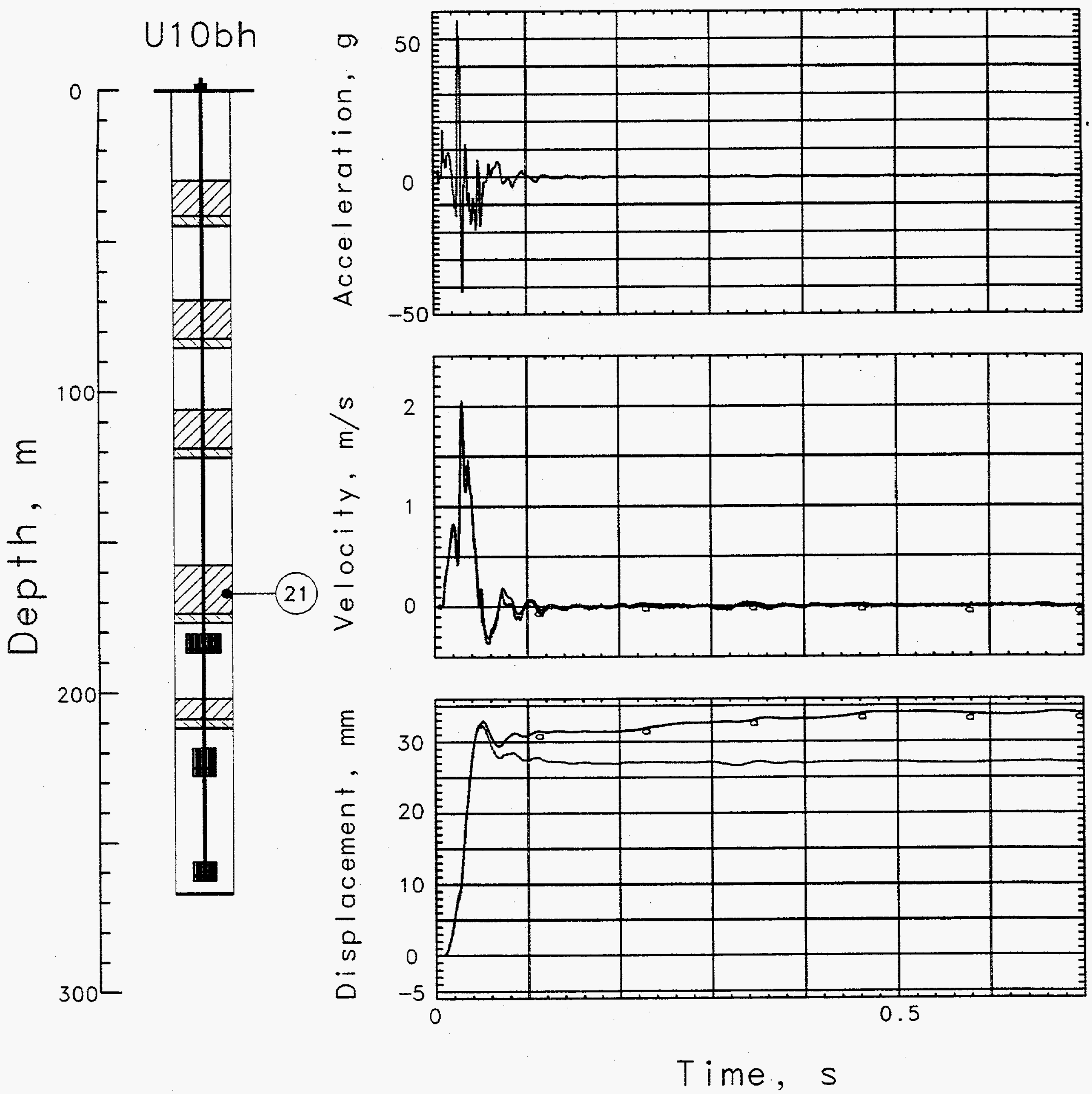


Figure 3.14 Explosion–induced vertical motion of plug #2 at a depth of 166 m (station 21). Records annotated with an 'a' are derived from the accelerometer.

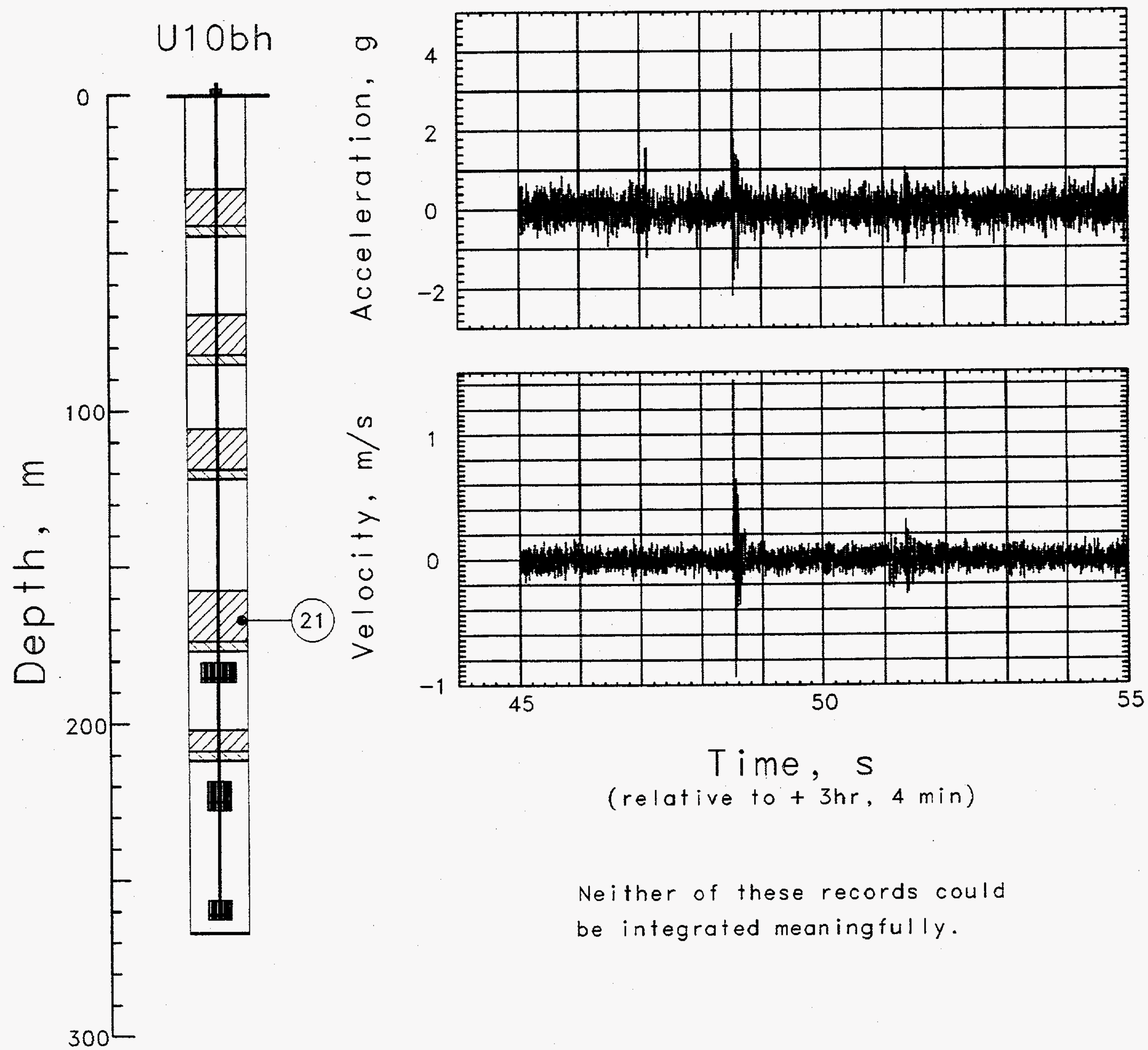


Figure 3.15 Possible collapse–induced signals in plug #2 at a depth of 166 m (station 21). No discernible displacement was detected.

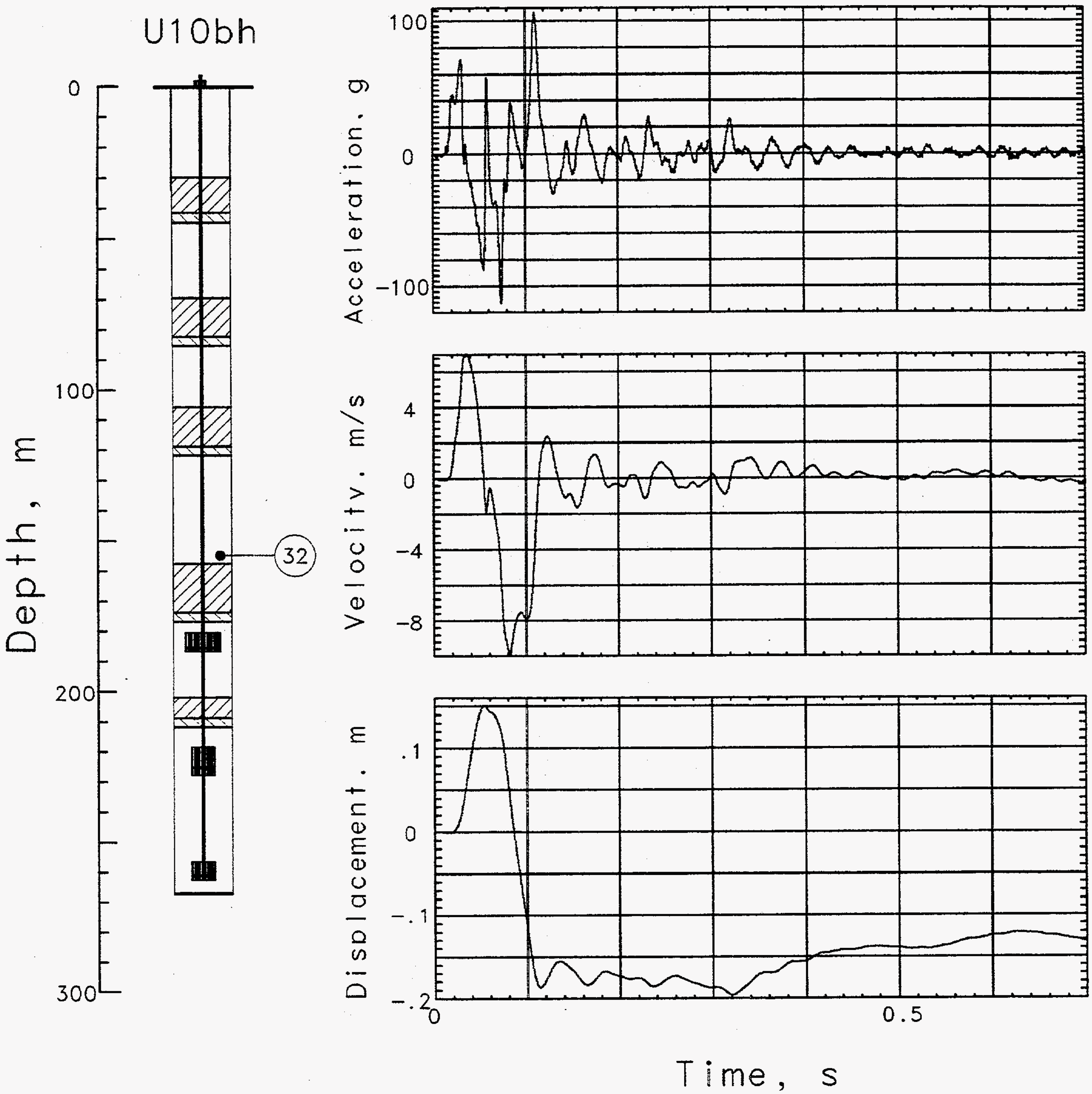


Figure 3.16 Explosion–induced vertical motion in the coarse of the emplacement hole at a depth of 152 m (station 32, above plug #2).

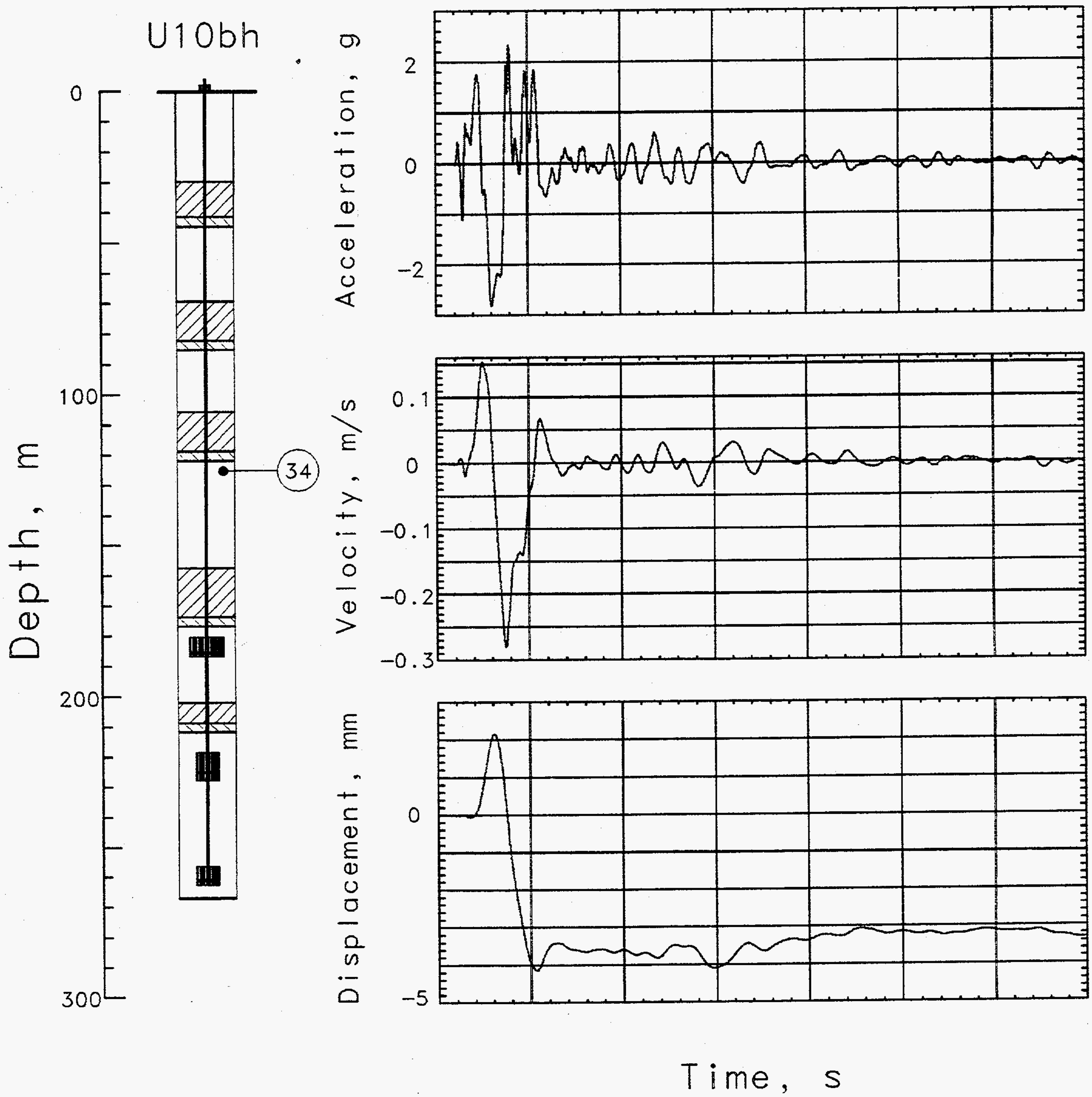


Figure 3.17 Explosion–induced vertical motion in the coarse stemming of the emplacement hole at a depth of 122 m (station 34, below plug #3).

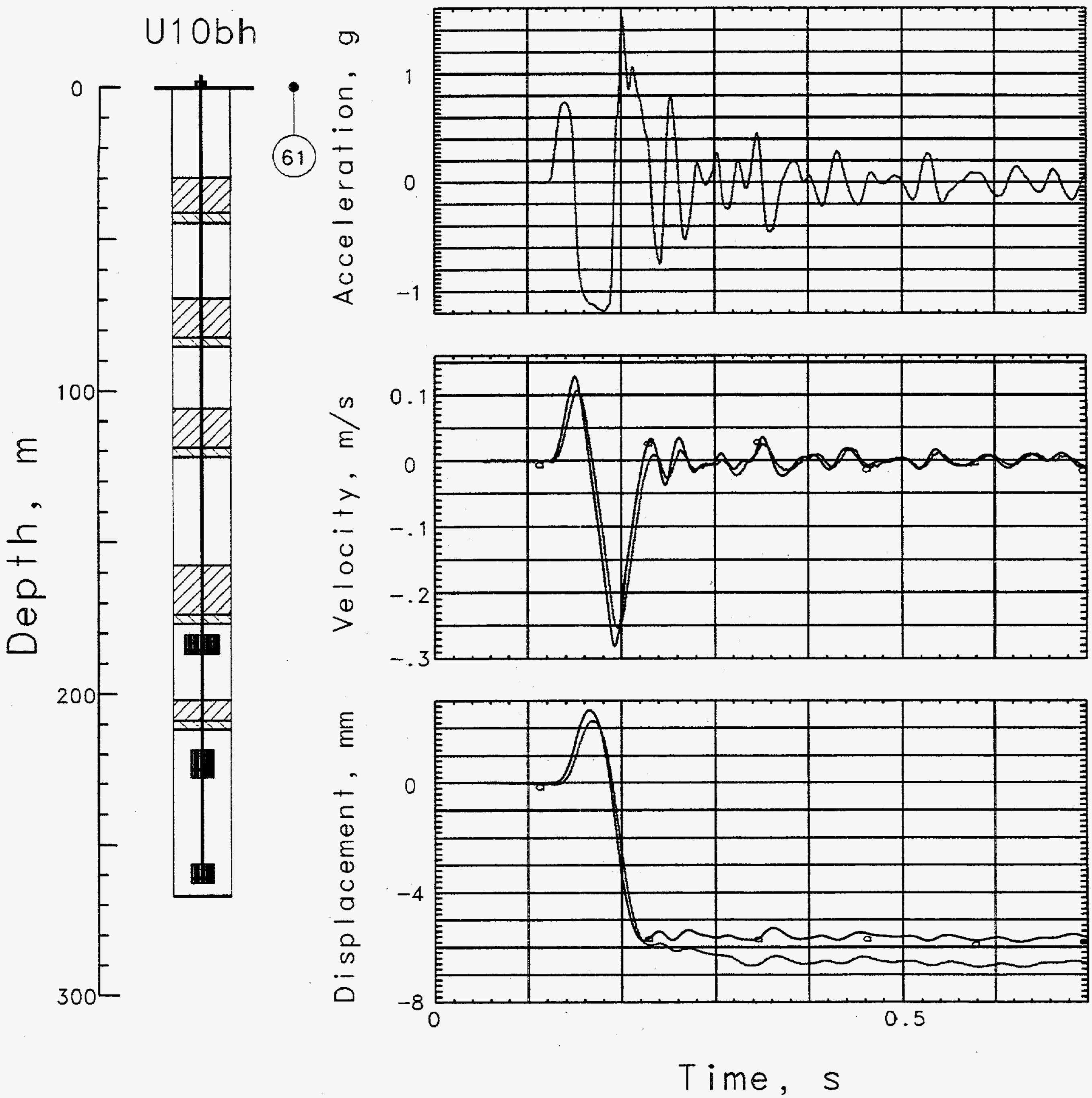


Figure 3.18 Explosion–induced vertical motion 0.91 m deep in the ground surface at a horizontal distance of 15.24 m from Surface Ground Zero (station 61). Records annotated with an 'a' are derived from the accelerometer.

4. Other Measurements

4.1 Motion in the LLNL trailer park

Figures 4.1–4.3 show the explosion–induced triaxial motion of the recording trailer. Figure 4.4 shows data as recorded on a high sensitivity accelerometer and a geophone mounted in the ground surface of the trailer park (station 63). With the exception of the initial shock, the ground motion produced by HAZEBROOK was almost nonexistent.

Table 4.1 Summary of Motion

Gauge	Slant Range (m)	Arrival Time (ms)	Acceleration Peak (g)	Velocity Peak (m/s)	Displacement Peak (mm)	Displacement Resid. (mm)
71av	208[a]	140	0.40	0.041	1.0	-1.2
71uv		-	-	0.042	1.0	-0.5
71ar[b]	208[a]	145	0.45	0.046	0.5	-1.4
71ur[b]		-	-	0.10	1.7	-3
71at	208[a]	145	0.20	0.013	2[c]	(c)
71ut		-	-	0.013	0.3, -0.4	-0.1

(a) Range is approximate: station is in trailer.
(b) Difference in wave form amplitudes is probably due to a calibration error.
(c) Baseline offset very difficult to remove.

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	0.67	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	20.15	7
71ur	3.516	9.59	24.42	20.15	5
71ut	3.354	8.87	25.41	20.15	5

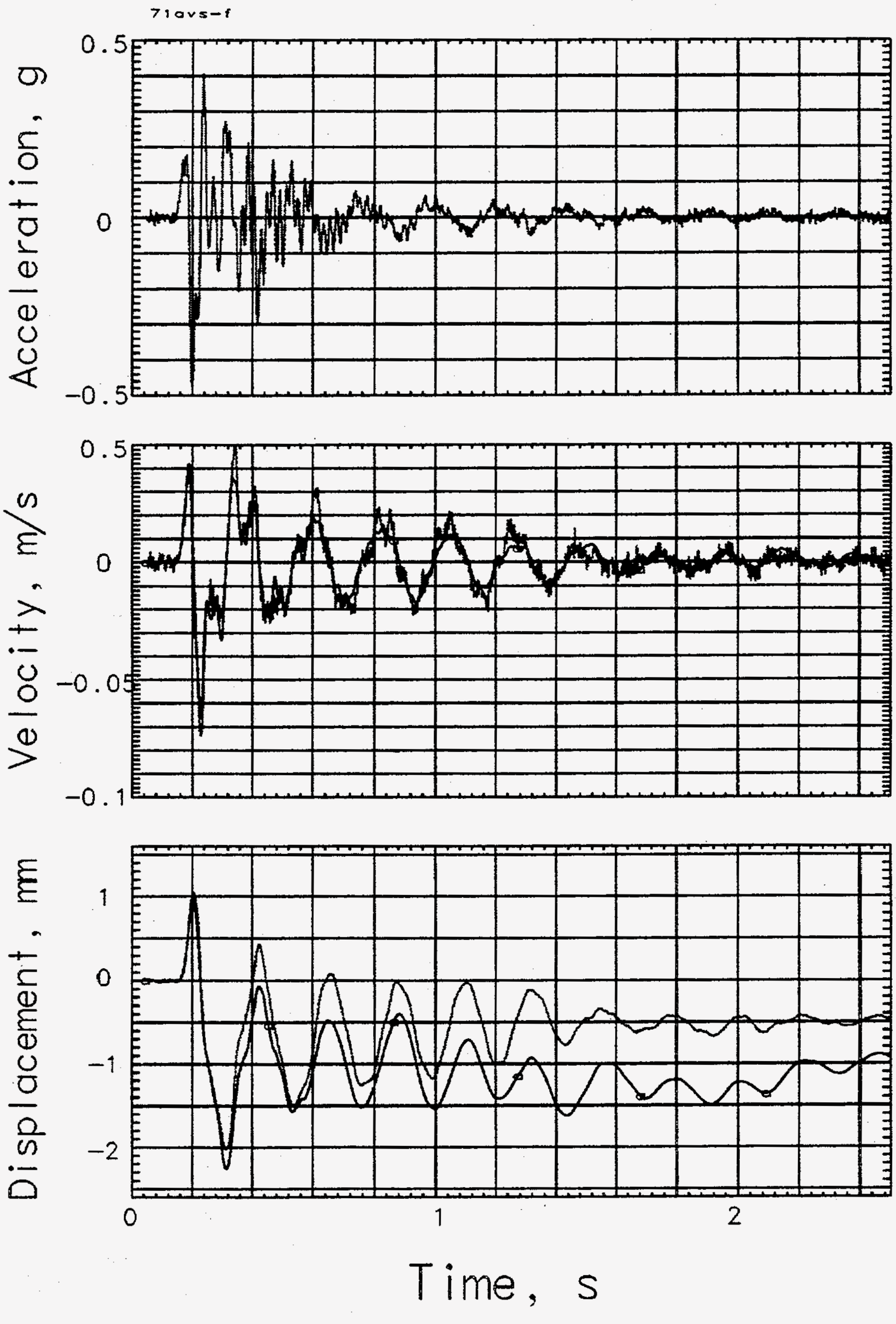


Figure 4.1 Explosion-induced vertical motion of the recording trailer (station 71). Records annotated with an 'a' are derived from the accelerometer.

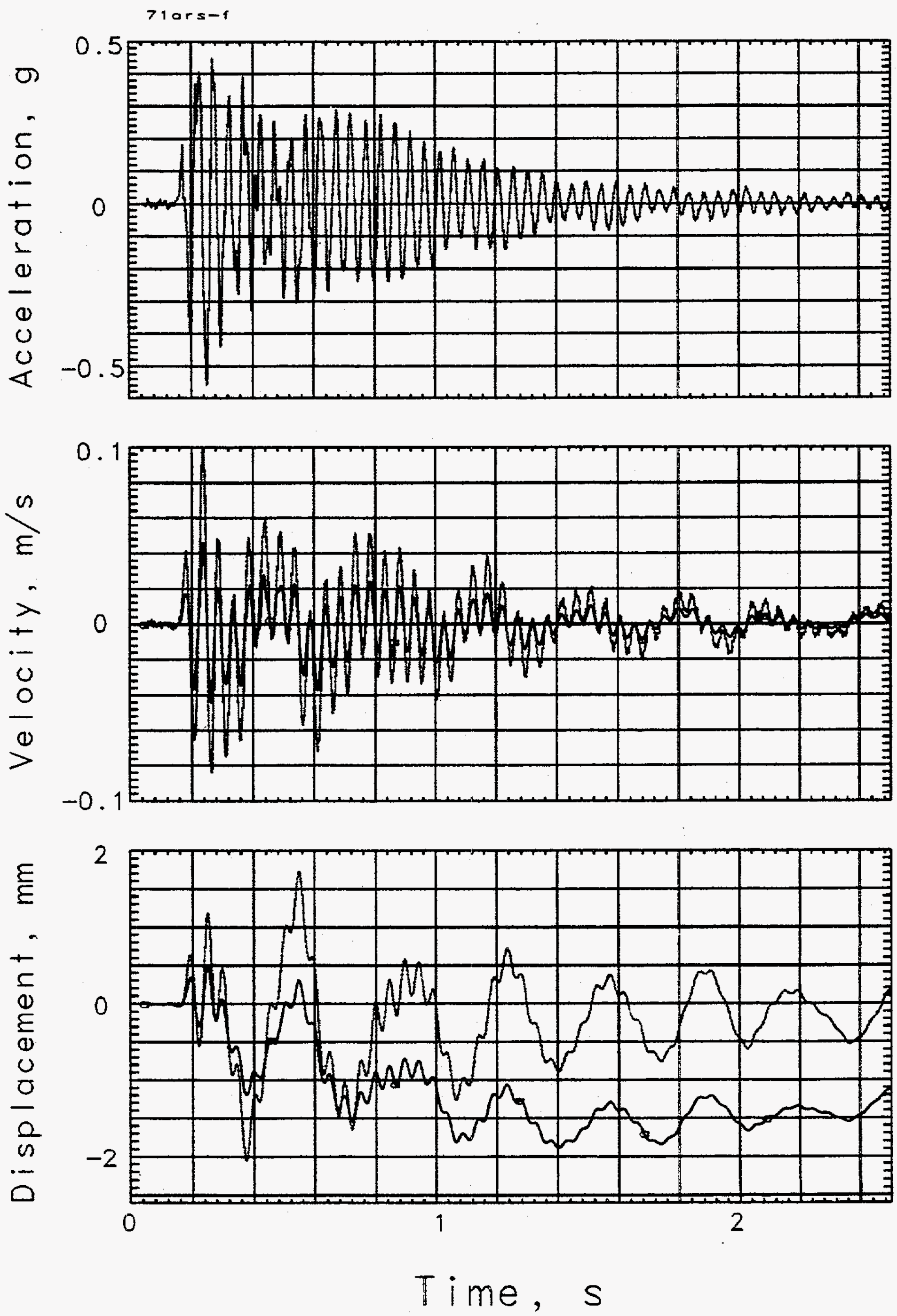


Figure 4.2 Explosion–induced horizontal–radial motion of the recording trailer (station 71). Records annotated with an 'a' are derived from the accelerometer.

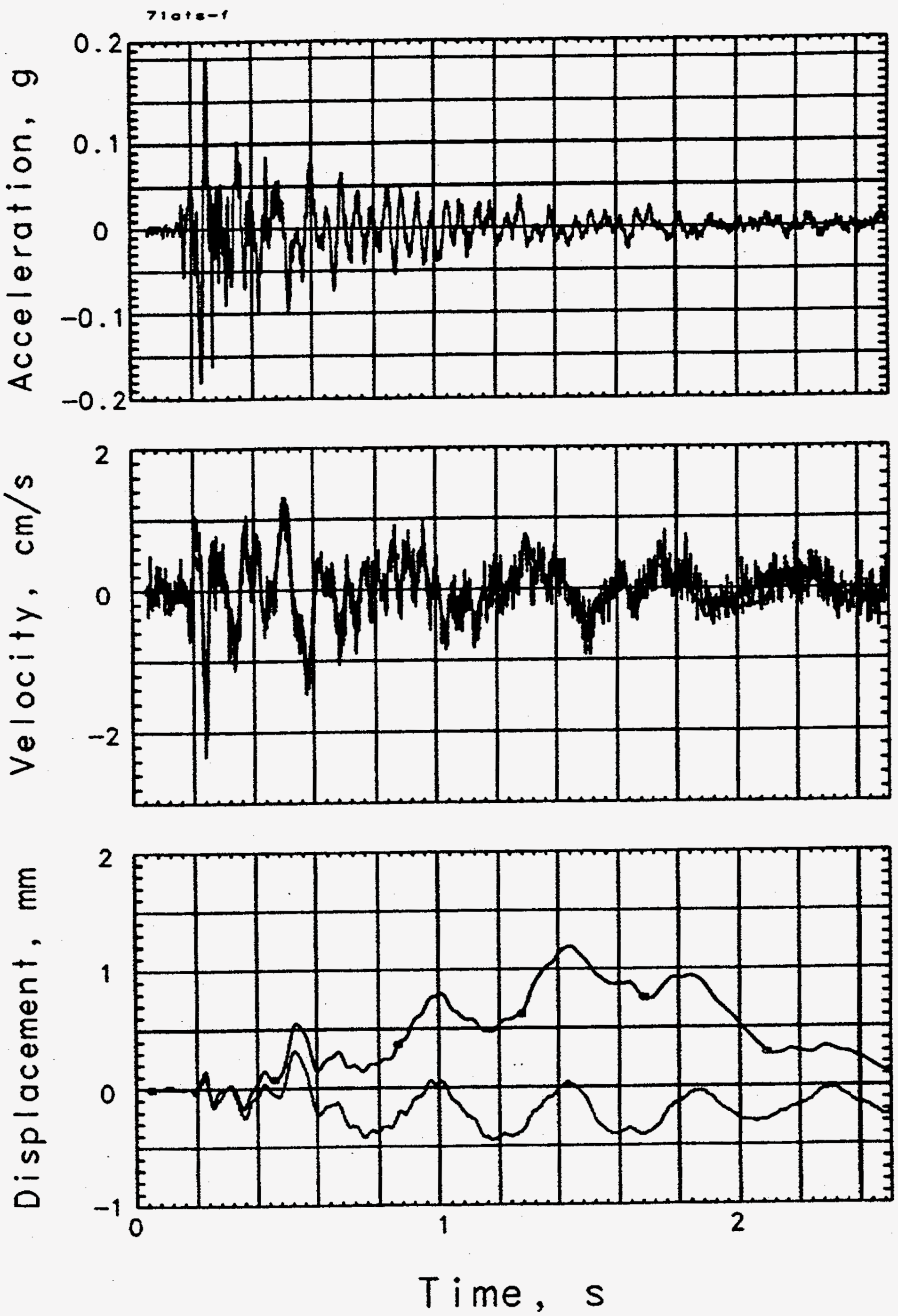


Figure 4.3 Explosion–induced horizontal–transverse motion of the recording trailer (station 71). Records annotated with an 'a' are derived from the accelerometer.

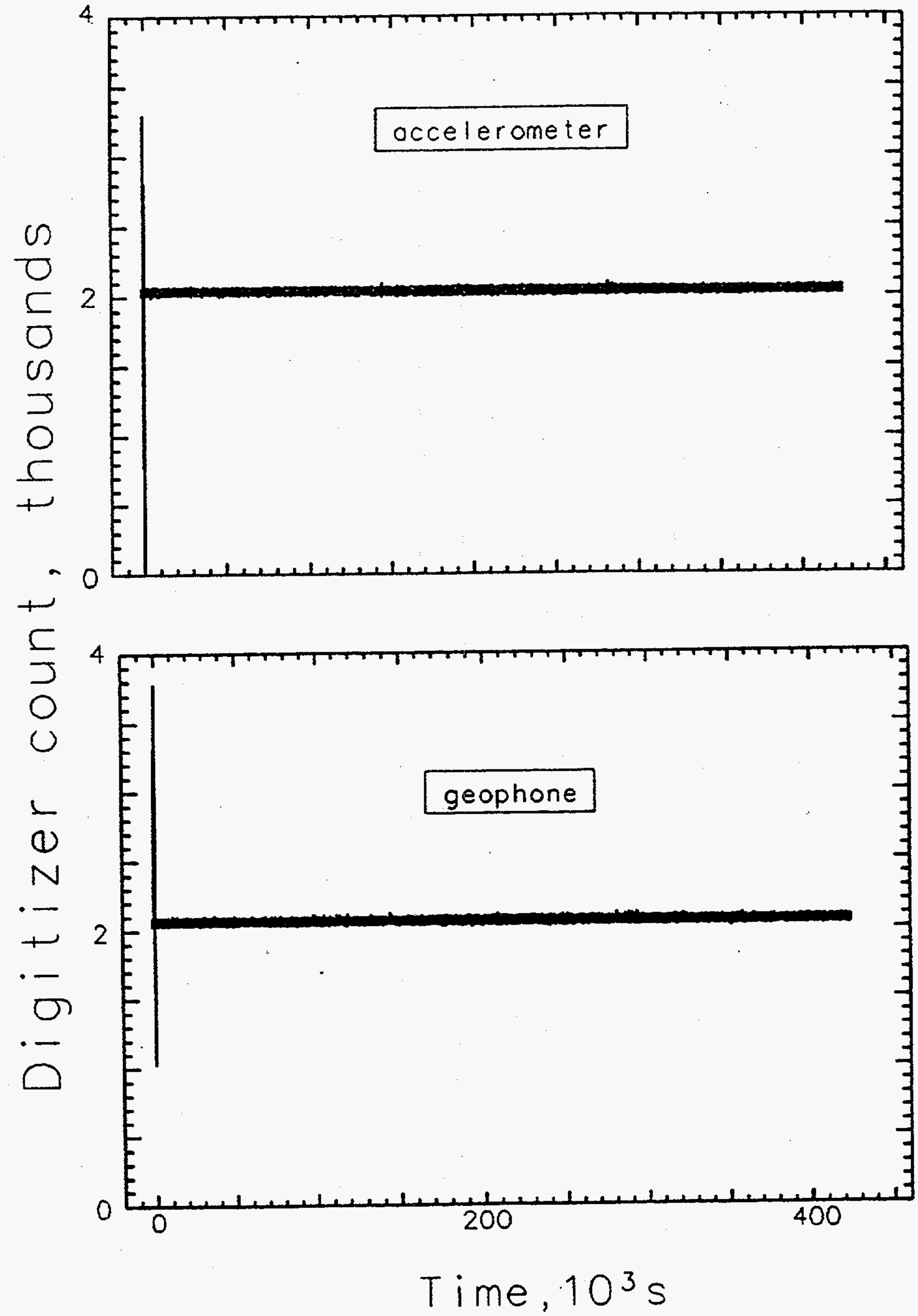


Figure 4.4 Data from the vertical geophone and sensitive accelerometer mounted in the ground surface at the recording trailer (station 63). Note that there is no detectable motion after the first explosion–induced shock.

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