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**AKAVI
Containment Data Report**

T. Stubbs

R. Heinle

August 1995

Lawrence
Livermore
National
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AKAVI Instrumentation Summary

Instrumentation	Fielded on this Event	Data Return	Present in this Report
<u>Plug Emplacement</u>	yes	yes	yes
<u>Radiation</u>	yes	yes	yes
<u>Pressure</u>			
Stemming	yes	yes	yes
Challenge	no	-	-
Cavity	no	-	-
Atmospheric	no	-	-
<u>Motion</u>			
Free Field	no	-	-
Surface	yes	yes	yes
Plug	yes	yes	yes
Stemming	no	-	-
Surface Casing	no	-	-
Emplacement Pipe	no	-	-
<u>Hydroyield (a)</u>	yes	yes	no
<u>Collapse (b)</u>	yes	yes	yes
<u>Stress</u>	no	-	-
<u>Strain (c)</u>	yes	no	-
<u>Other Measurements</u>	no	-	-

- (a) CORTEX and/or SLIFER in emplacement hole.
(b) EXCOR or CLIPER in emplacement hole.
(c) Emplacement pipe load.

Event Personnel

Containment Physics

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Contents

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1. Event Description

1.1 Site

The AKAVI event was detonated in hole U2es of the Nevada Test Site as indicated in figure 1.1. The device had a depth-of-burial (DOB) of 494 m in the Paintbrush Tuff of area 2, about 90 m above the standing water level and 300 m above the Paleozoic formation, as shown in figures 1.2 and 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⁾.

Detonation time was 07:00 PST on December 3, 1981 and 103 minutes later a surface collapse occurred leaving a crater with mean radius of 90.5 m and maximum depth of 19.5 m.

No radiation arrivals were detected above ground and the AKAVI containment was considered successful.

1.2 Instrumentation

Figure 1.5 is a schematic layout of the instrumentation designed to monitor the emplacement procedures and stemming performance of the AKAVI event.

The three stemming plugs were composed of coal-tar epoxy (LAE 59, denoted CTE). A soft layer of coal-tar and aggregate (LAE 59MY, denoted CTA) was poured on the top of each of the plugs to act as a gas seal.

Pressure and radiation were monitored in the loose stemming about 1.5 m below the top plug.

Vertical motion was monitored in the recording trailer and in the ground surface, 15.24 m due north of SGZ. An array of fourteen motion stations was fielded on a line approximately [S 83° W] from surface ground zero (SGZ) with each buried 0.91 m in the ground surface. These gauges added to the seismic survey information around the CARPETBAG fault lying about 2.5 Km to the west of U2es, in preparation for an experiment to be carried out in hole U2fe (shown in figure 1.6). The closest station to SGZ was at a horizontal distance of 900 m while each succeeding station was 100 m farther away. All surface stations were buried at a depth of 0.9 m in the ground surface. Vertical motion was monitored at each of the fourteen stations but, because of a limitation of both available transducers and recording channels, tri-axial motion was monitored at only four stations and an additional four measured bi-axial motion (horizontal-radial and vertical components).

Data from each of the above instruments were transmitted to the recording trailer by an analog system and recorded on magnetic tape.

D-cable information was used for quality assurance during the stemming operations and to monitor the collapse process.

One CLIPER sensor, one CORTEX sensor and four SLIFER cables were emplaced in the emplacement hole to measure the hydrodynamic yield of the device and to monitor cavity collapse and chimney formation. Results of the yield measurements are reported elsewhere⁽³⁾.

A history of the fielding operations of the instrumentation is outlined in reference 4. Details of the instrumentation are given in reference 5.

1.3. Emplacement

A single strain station (84) was fielded near the top of the emplacement pipe to monitor the load during installation and stemming. At the end of each day during these procedures, output of this station was recorded by hand in the stemming log maintained by Holmes & Narver⁽²⁾.

The stemming plugs consisted of three "LAE 59" coal-tar epoxy (CTE) layers. The bottom plug was about 6 m thick while the top two were about 4 m thick. All plugs were capped with about 2 m of soft coal-tar-aggregate "LAE 59MY" epoxy (CTA) to act as a gas sealant. Stemming between the plugs consisted of layers of fines and coarse gravel. The top of the hole (above the top plug) was filled with ground surface derived backfill and the inside of the emplacement pipe was grouted for its full length. See figure 1.4.

Figure 1.1 Map of the Nevada Test Site indicating the location of hole U2es.

Figure 1.2 North-South geologic cross sections through hole U2es.

Figure 1.3 Southwest-Northeast geologic cross sections through hole U2es.

Figure 1.4 As-built stemming plan for the event AKAVI in Hole U2es.

Figure 1.5 As-built containment instrumentation plan for the emplacement hole (U2es) on the AKAVI event.

Figure 1.6 As-built surface array motion instrumentation for the AKAVI event showing the location of neighboring holes and the surface expression of the CARPETBAG fault.

2. Stemming Performance

2.1 Radiation and Pressure

As seen in figure 1.5, pressure and radiation were monitored in the coarse stemming at only one station, about 1.5 m below the top plug. Wave forms of the pressure and radiation measured at this station are shown in figure 2.1 for times beginning about 1 minute before detonation and lasting for about 3 hours.

2.3 Motion

Explosion-induced histories of the containment related motion measured on the AKAVI event are shown in figures 2.2 and 2.3. Characteristics of the associated motion and transducers are given in tables 2.1–2.3.

2.4 Collapse phenomena

No CLIPER data are available and the D-cable information was recorded but not reduced. Recordings of the D-cable suggest that a collapse began at 6163.5 s with a final episode at 6168.3 s. These times correlate well with the ground surface collapse motion of station 61, shown in figure 2.4.

There was sufficient surface slack in the instrumentation cables to allow both station 61 and the D-cable to survive the collapse. Pressure and radiation wave forms obtained during a period of 100 s covering the collapse are shown in figure 2.5. Characteristics of the pressure wave form suggest that there was first a stemming fall, reducing the pressure below the top plug, followed by a collapse of the surface that induced a compression at the station. The radiation wave form of figure 2.5 suggests the possibility of radiation at station 31. However, the rise is so abrupt and the wave form decays so quickly, it is suspected that this was caused by movement of the source chip in the detector, not gas radiation. The long term stability of the record seen in figure 2.1 tends to confirm this.

The pressure and radiation data are consistent with satisfactory containment.

Figure 2.1 Pressure and radiation measured in the loose stemming at 38.1 m depth (Station 31, below the top stemming plug 1).

Figure 2.2 Explosion-induced vertical motion of the ground surface at a horizontal range of 15.24 m and a depth of 0.9 m (station 61).

Figure 2.3 Explosion-induced vertical motion of the recording trailer (station 79).

Figure 2.4 Collapse-induced vertical motion of the ground surface at a horizontal range of 15.24 m and a depth of 0.9 m (station 61).

Figure 2.5 Pressure and radiation measured in the loose stemming at 38.1 m depth during collapse (Station 31, below the top stemming plug 1).

Table 2.1 Summary of Containment-Related Motion

Gauge	Slant Range (m)	Arrival Time (ms)	Acceleration Peak (g)	Velocity Peak (m/s)	Displacement Peak (cm)	Displacement Residual (cm)
61av	493.6	272	1.6, 9.2(a)	0.72	11.2	-7
61uv		-	-	0.68	10.0	-5
79av	529(b)	313	1.7, 3.7(a)	0.80	9.3	-6
79uv		-	-	0.77	8.8	-0.5

(a) Slap-down.

(b) Estimate: Transducer was in recording trailer.

Table 2.2 Containment-Related Accelerometer Characteristics

Gauge	Natural Frequency (Hz)	Damping Ratio	System Range (g's)
61av	575	0.65	50
79av	220	0.65	10

Table 2.3 Containment-Related Velocimeter Characteristics

Gauge	Natural Frequency (Hz)	Time to 0.5 Amplitude (s)	Calibration Temperature (°F)	Operate Temperature (°F)	System Range (m/s)
61uv	3.48	15.4	73.9	50.41	10
79uv	4.00	20.4	73.86	64.51	2

3. Surface array measurements

Figures 3.1 - 3.26 show the motion obtained from the surface array lying on a line [S 83° W] from U2es, as shown in figure 1.6. The first station was at a horizontal range of 900 m from U2es with each succeeding station 100 m farther along the line. All stations were buried 0.91 m in the ground surface. All stations monitored vertical motion, four of the fourteen stations included tri-axial motion measurements (vertical, horizontal-radial, and horizontal-transverse) and an additional four included bi-axial measurements (vertical and horizontal-radial). Positive sense motion was vertical, radial outward, and clockwise looking down on the station. Tables 3.1 - 3.3 summarize the motion and the motion transducer properties.

First arrivals of the motion are plotted in figure 3.27. The sound speed, as determined by the slope of the line drawn in figure 3.27 (2250 m/s), is consistent with the Working Point data derived from the vibroseis measurements⁽¹⁾. These data define the lateral position of a scarp in the underlying Paleozoic formation (to within the 100 m limits set by the station spacing). Appendix A is a detailed analysis of this information, performed by V. Wheeler.

Figures 3.28 and 3.29 show the peak acceleration and velocity as a function of range from the detonation point. Both vertical and horizontal- radial motion are represented in figures 3.28 - 3.29.

Table 3.1 Summary of Surface Array Motion

Gauge	Slant Range (m)	Arrival Time (ms)	Acceleration Peak (g)	Velocity Peak (cm/s)	Displacement Peak (mm)
62av	1030.4	545	0.3	22.0	23
62uv		545	-	21.0	21.8
62ar		554	0.185	16.4	35.5
62at		557	0.075	6.3	9.5
63av	1119.4	588	0.28	19.5	19.5
63uv		588	-	22.0	21.5
64av	1209.6	625	0.23	18.0	16.8
64uv		625		17.5	16.2
64ar		625	0.21	19.0	33.7
65av	1301.9	672	0.11	16.0	14.3
65uv		672	-	18.0	16.6
66av	1395.0	709	0.17	10.0	8.2
66uv		709	-	16.0	13.2
66ar		709	0.20	16.0	32.5
66at		709	0.087	7.3	7.8
67av	1488.5	752	0.18	12.0	8.5
67uv		752	-	15.0	10.8
67ar		752	0.20	14.0	30.5
68av	1583.9	779	0.16	8.2	5.9
68uv		779	-	6.8	4.7
68ar		790	0.14	9.7	23.2
69av	1679.1	795	0.086	4.3	3.5
69uv		795	-	4.4	3.5

Table 3.1 Summary of Surface Array Motion (continued)

Gauge	Slant Range (m)	Arrival Time (ms)	Acceleration Peak (g)	Velocity Peak (cm/s)	Displacement Peak (mm)
70av	1775.2	785	0.031	2.0	2.1
70uv		785	-	2.3	2.4
70ar		830	0.035	4.1	11.1
70at		853	0.036	2.9	0.60
71av	1871.4	757	0.021	1.5	1.3
71uv		757	-	1.5	1.3
72av	1968.1	753	0.014	1.0	1.0
72uv		753	-	1.0	1.1
72ar		880	0.035	7.8	18.4
73av	2064.9	745	0.012	0.9	1.0
73uv		745	-	0.9	1.0
74av	2162.2	760	0.014	1.0	1.0
74uv		760	-	0.66	0.70
74ar		765	0.007	8.9	23.0
74at		760	-0.003	-0.3	-0.04
75av	2259.6	766	0.015	0.9	1.0
75uv		766	-	1.2	1.0

Note: Positive values denote vertically upward (v), horizontal-radial outward (r), and horizontal-transverse with clockwise motion (t).

Table 3.2 Surface Array Accelerometer Characteristics

Gauge	Natural Frequency (Hz)	Damping Ratio	System Range (g's)
62av	150	0.65	3
62ar	280	0.60	3
62at	140	0.75	3
63av	142	0.65	3
64av	251	0.75	3
64ar	239	0.65	3
65av	210	0.75	3
66av	240	0.65	3
66ar	262	0.65	3
66at	269	0.60	3
67av	270	0.85	3
67ar	200	0.65	3
68av	178	0.65	2
68ar	74	0.65	2
69av	170	0.65	2
70av	118	0.65	2
70ar	70	0.65	2
70at	140	0.75	2
71av	141	0.65	2
72av	112	0.70	1
72ar	110	0.65	1
73av	132	0.65	1
74av	74	0.65	1
74ar	108	0.65	1
74at	120	0.65	1
75av	68	0.65	1

Table 3.3 Surface Array Velocimeter Characteristics

Gauge	Natural Frequency (Hz)	Time to 0.5 Amplitude (s)	Calibration Temperature (°F)	Operate Temperature (°F)	System Range (m/s)
62uv	3.55	9.5	74.1	49.95	1
63uv	3.40	9.4	75.4	54.69	1
64uv	3.60	13.9	74.5	53.38	1
65uv	3.49	12.7	74.7	52.01	1
66uv	3.62	12.8	74.5	55.98	1
67uv	3.50	11.9	73.5	55.12	1
68uv	3.31	15.2	73.7	47.10	1
69uv	3.28	19.3	73.8	55.56	1
70uv	3.25	25.0	75.1	49.48	1
71uv	3.43	13.4	74.2	50.41	1
72uv	3.46	13.2	72.8	49.25	1
73uv	3.62	10.9	73.5	53.58	1
74uv	3.51	10.8	74.4	54.91	1
75uv	3.24	22.5	74.3	50.41	1

Figure 3.1 Vertical motion of the ground surface at a slant range of 1030.4 m and a depth of 0.91 m (station 62).

Figure 3.2 Horizontal-radial motion of the ground surface at a slant range of 1030.4 m and a depth of 0.91 m (station 62).

Figure 3.3 Horizontal-transverse motion of the ground surface at a slant range of 1030.4 m and a depth of 0.91 m (station 62).

Figure 3.4 Vertical motion of the ground surface at a slant range of 1119.4 m and a depth of 0.91 m (station 63).

Figure 3.5 Vertical motion of the ground surface at a slant range of 1209.6 m and a depth of 0.91 m (station 64).

Figure 3.6 Horizontal-radial motion of the ground surface at a slant range of 1209.6 m and a depth of 0.91 m (station 64).

Figure 3.7 Vertical motion of the ground surface at a slant range of 1301.9 m and a depth of 0.91 m (station 65).

Figure 3.8 Vertical motion of the ground surface at a slant range of 1395.0 m and a depth of 0.91 m (station 66).

Figure 3.9 Horizontal-radial motion of the ground surface at a slant range of 1395.0 m and a depth of 0.91 m (station 66).

Figure 3.10 Horizontal-transverse motion of the ground surface at a slant range of 1395.0 m and a depth of 0.91 m (station 66).

Figure 3.11 Vertical motion of the ground surface at a slant range of 1488.5 m and a depth of 0.91 m (station 67).

Figure 3.12 Horizontal-radial motion of the ground surface at a slant range of 1488.5 m and a depth of 0.91 m (station 67).

Figure 3.13 Vertical motion of the ground surface at a slant range of 1583.9 m and a depth of 0.91 m (station 68).

Figure 3.14 Horizontal-radial motion of the ground surface at a slant range of 1583.9 m and a depth of 0.91 m (station 68).

Figure 3.15 Vertical motion of the ground surface at a slant range of 1679.1 m and a depth of 0.91 m (station 69).

Figure 3.16 Vertical motion of the ground surface at a slant range of 1775.2 m and a depth of 0.91 m (station 70).

Figure 3.17 Horizontal-radial motion of the ground surface at a slant range of 1775.2 m and a depth of 0.91 m (station 70).

Figure 3.18 Horizontal-transverse motion of the ground surface at a slant range of 1775.2 m and a depth of 0.91 m (station 70).

Figure 3.19 Vertical motion of the ground surface at a slant range of 1871.4 m and a depth of 0.91 m (station 71).

Figure 3.20 Vertical motion of the ground surface at a slant range of 1968.1 m and a depth of 0.91 m (station 72).

Figure 3.21 Horizontal-radial motion of the ground surface at a slant range of 1968.1 m and a depth of 0.91 m (station 72).

Figure 3.22 Vertical motion of the ground surface at a slant range of 2064.9 m and a depth of 0.91 m (station 73).

Figure 3.23 Vertical motion of the ground surface at a slant range of 2162.2 m and a depth of 0.91 m (station 74).

Figure 3.24 Horizontal-radial motion of the ground surface at a slant range of 2162.2 m and a depth of 0.91 m (station 74).

Figure 3.25 Horizontal-transverse motion of the ground surface at a slant range of 2162.2 m and a depth of 0.91 m (station 74).

Figure 3.26 Vertical motion of the ground surface at a slant range of 2259.6 m and a depth of 0.91 m (station 75).

Figure 3.27 Arrival times of the first motion as a function of distance from the detonation point. All measured components of motion are represented. There is indication of a scarp in the Paleozoic formation around a range of 1600 m.

Figure 3.28 Peak initial acceleration as a function of distance from the detonation point. Both vertical and horizontal-radial motion are represented.

Figure 3.29 Peak initial velocity as a function of distance from the detonation point. Both vertical and horizontal-radial motion are represented.

References

1. Nancy W. Howard, "U2es Preliminary Site Characteristics Summary", DM 81-59, Lawrence Livermore National Laboratory, Livermore, CA, August 4, 1981.
2. George Kronsbein, "Containment Report for U2es," Holmes & Narver, NTS:A2:81-112, December 1, 1981.
3. LLNL contacts for additional information: R. A. Heinle (CORTEX and SLIFER data)
4. Troy L. Williams, "Special Measurements Final Engineering Report AKAVI, U2es", EG&G, Energy Measurements, Las Vegas, NV, SM:81E-92-34, 13 January, 1982.
5. William G. Webb, "Special Measurements Physics/Instrumentation Package for AKAVI, U2es, Revision 'A', Final", EG&G, Energy Measurements, Las Vegas, NV, SM:81E-92-35, 13 January, 1982.
6. Nancy W. Howard and Jeff Wagoner, "U2fe Site Characteristics Summary", DM 82-64, Lawrence Livermore National Laboratory, Livermore, CA, November 1, 1982.

Appendix A.

The Paleozoic Surface in the Vicinity of U2fe as Defined by the AKAVI Seismic Experiment"

September 14, 1982

MEMORANDUM

TO: Distribution

FROM: V. E. Wheeler

SUBJECT: The Paleozoic Surface in the Vicinity of U2fe
as Defined by the AKAVI Seismic Experiment

The AKAVI explosion was used as a source to do a rough seismic survey of the Carpetbag Fault in the vicinity of U2fe. This survey confirms the location of the faults deduced from gravity data.

A detailed description and the results of the AKAVI ground motion experiment are presented in the AKAVI Final Data Report by Wheeler and Stubbs (UCID 19553).

Summarizing the experiment, a line of 14 surface motion stations was run to the west of U2es (AKAVI) passing 118 m north of U2fe and ending 166 m south of the exploratory hole, UE2ab. The stations were spaced 100 m apart with the first station 900 m from U2es and the last station at 2200 m.

Both U2es and U2fe are located in a 3000 m wide basin bounded on the east by the Yucca Fault and on the west by the Carpetbag Fault. U2es is approximately 1000 m into the basin (1000 m west of the Yucca Fault) and U2fe is on the west side of the basin near the Carpetbag Fault. The Paleozoics are estimated to be at a depth of 785 m at U2es, dipping downward to about 900 m to the west and then rising to approximately 830 m in the vicinity of U2fe. In the basin, 300 to 400 metres of tuff are overlain by several hundred metres of alluvium; while to the west of the Carpetbag Fault the Paleozoics are directly overlain by alluvium.

The measured arrival times were used with the geometry shown in Fig. 1 to compute a location for the uplift of the Paleozoics in the area of U2fe. In this geometry, the Paleozoic surface in the basin is assumed to be flat and at a depth of 850 m. The time for the shock wave to reach the Paleozoics was arbitrarily set at 140 ms which reduces the error introduced by the assumption that the Paleozoics are assumed deeper than the estimated depth under U2es. The angle of refraction between the tuff and Paleozoics is taken as 30° ($V_t/V_p = 0.5$). Using the ray path numbered 4 on Fig. 1, the measured depth to Paleozoics and the measured average velocity from the Paleozoics to the surface in UE2ab, and the measured arrival time at the 2200 m station a Paleozoic velocity of 5500 m/s was calculated. Using this velocity for the Paleozoics and the path labeled 2, a velocity of 2000 m/s from the Paleozoics to the surface was computed for the overburden within the basin.

Using the above data, Fig. 2 was constructed. The measured arrival times are red +. The upper blue line are the computed arrival times assuming the flat Paleozoic surface continues beyond the gage line at a depth of 850 m. The lower green line are the computed arrival times assuming the Paleozoic surface rises to 363 m depth between U2es and the first gage at 900 m and then continues at that depth to beyond the gage line. This is shown as the dashed blue line in Fig. 1. The ray path labeled 1 was moved from station to station and the arrival time for each station calculated. Figure 2 shows the direct wave as the first arrival out to 1500 m with the Paleozoic refracted wave becoming the first arrival from 1500 m on. A definite rise in the Paleozoics has occurred at 1700 m range and continues to rise to the end of the gage line.

In Fig. 3 the location of the Paleozoic surface was computed using 5500 m/s for the velocity of the Paleozoics, the ray path labeled 3 (red) in Fig. 1 and two separate overburden velocities. Overplotted on this is the cross section through U2fe and UE2ab (shown in blue). The upper line of red +s are the location of the Paleozoic surface computed using an overburden velocity of 1700 m/s which is only true for the all alluvium overburden at the end of the gage line. The lower line of green +s are the computed location using an overburden velocity of 2000 m/s

which may be true for the tuffs and alluvium in the basin. The green line is thus a better representation of the Paleozoic surface where both tuffs and alluvium form the overburden while the red +s better represent the surface on top of the scarp where only alluvium overlies the Paleozoics.

This data well defines the horizontal location of the scarp, the accuracy being defined by the gage spacing of 100 m. The depth to the Paleozoics is ill defined. The depth to the Paleozoics below AKAVI is given as $785 \text{ m} \pm 78 \text{ m}$. Changing the time for the shock wave to reach the Paleozoics by $\pm .03$ seconds (the approximate travel time for 78 m) changes the computed Paleozoic depth by less than $\pm 5\%$ at the 1500 metre station and approaches $\pm 1\%$ at the 2200 metre station.

A larger error results from lack of knowledge of the overburden velocity at each station (with the exception of the 2200 metre station). As seen in Fig. 3, a change in average velocity from 1700 m/s to 2000 m/s changes the depth of the Paleozoics by 22%.

AKAVI Geometry
Fig. 1

Measured and Computed Travel Times

Fig. 2

Computed Paleozoic Surface

Fig. 3

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