# Office of Surface Mining Reclamation and Enforcement

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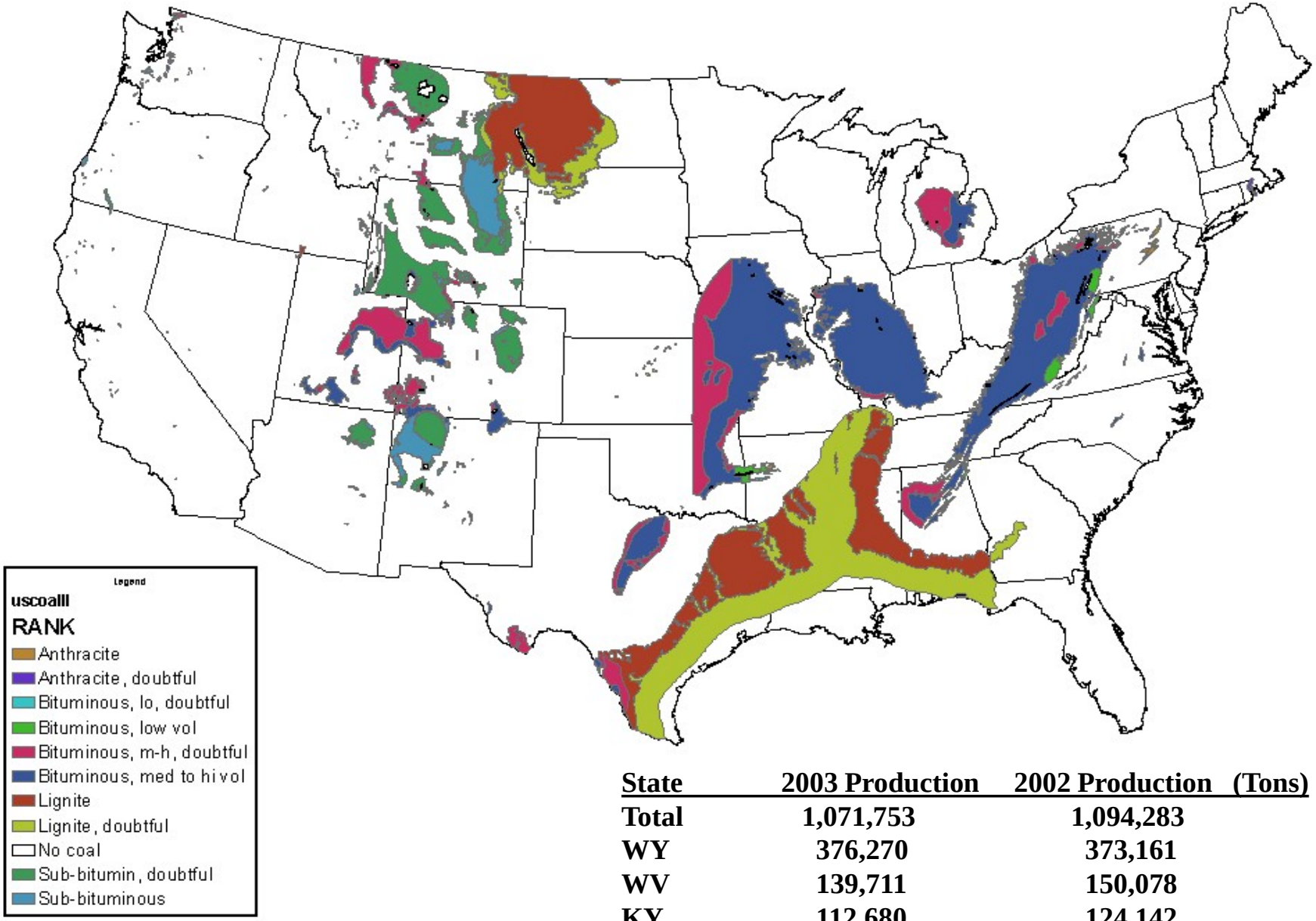
# Today

- Overview of OSM
- Discuss blasting at coal mines
- Review recordkeeping requirements
- How might the records help you.

# Coal Mining States



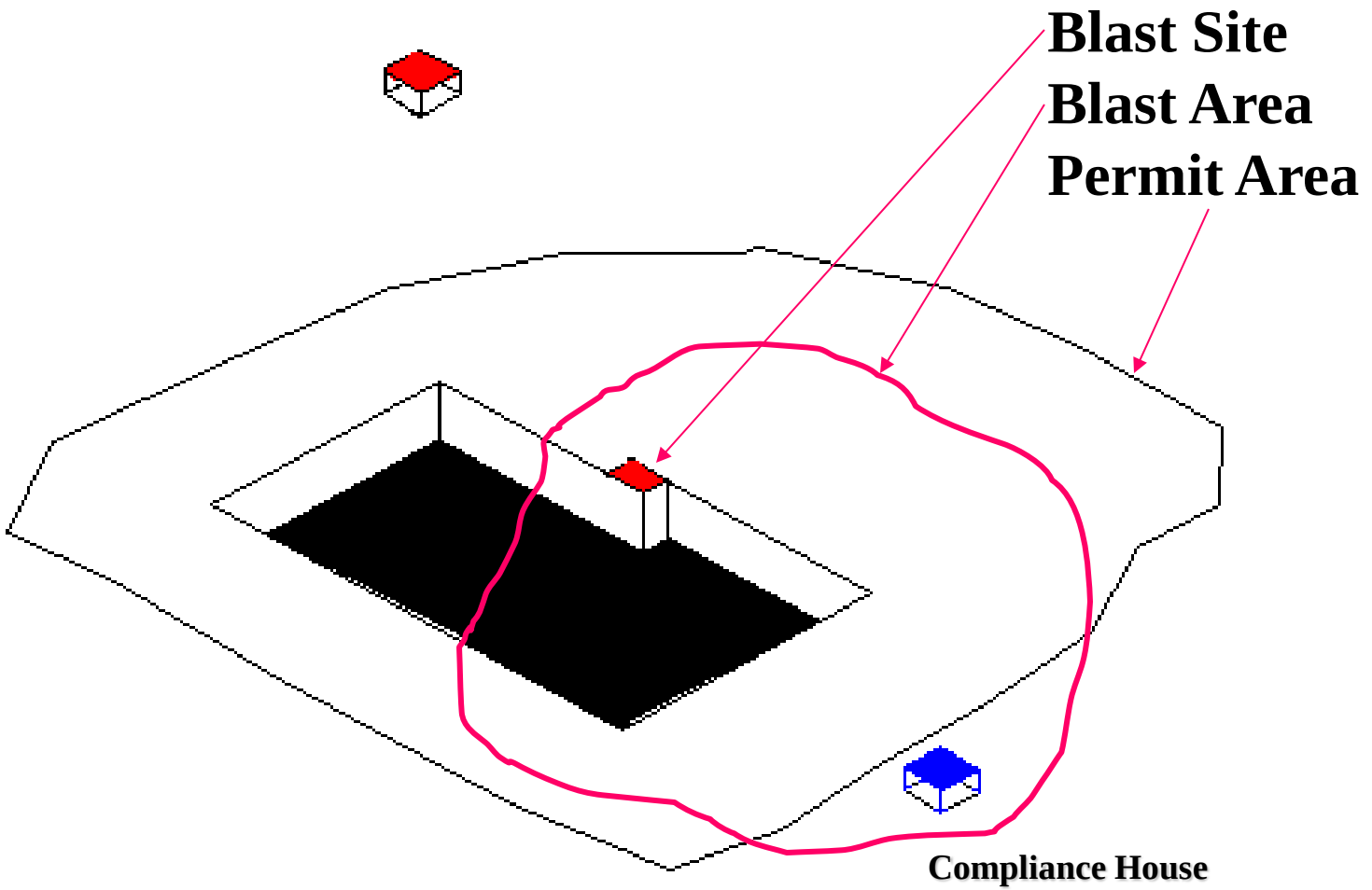

| State | 2003 Production | 2002 Production (Tons) |
|---|---|---|
| Total | 1,071,753 | 1,094,283 |
| WY | 376,270 | 373,161 |
| WV | 139,711 | 150,078 |
| KY | 112,680 | 124,142 |

# OSM Responsibilities

- Balance Nation's Energy Needs vs. Environmental Needs
- Fix Abandoned Mine Problems
  - Backfilling, Subsidence, Fires, Landslides, Water
- Regulate Active Mines – Surface effects
  - Reclamation/Land Productivity, Protect Water, Slope Stability, **Blasting Adverse Effects**
- Passes Responsibility to the States
  - OSM conducts oversight
  - Provides funding at 50%

# Worker Safety?  MSHA responsibility

# Coal Mine Terms



# Surface Mining Control and Reclamation Act of 1977 (SMCRA)

SECTION 515(b) General performance standards shall be applicable to all surface coal mining and reclamation operations and shall require the operation as a minimum to --

(15) insure that explosives are used only in accordance with existing State and Federal law and the regulations promulgated by the regulatory authority, which shall include provisions to -

(A) provide adequate advance **written notice** to local governments and residents who might be affected by the use of such explosives by publication of the planned blasting schedule in a newspaper of general circulation in the locality and by mailing a copy of the proposed blasting schedule to every resident living within **one-half mile of the proposed blasting site** and by providing **daily notice** to resident/occupiers in such areas prior to any blasting;

# SMCRA

**(**B) maintain for a period of at least **three years** and make available for public inspection upon request **a log** detailing the **location** of the blasts, the pattern and depth of the drill holes, the amount of **explosives used per hole**, and the **order and length of delays** in the blasts;

(C) limit the type of explosives and detonating equipment, the size, the timing and frequency of blasts based upon the physical conditions of the site so as to **prevent (i) injury to persons, (ii) damage to public and private property outside the permit area,** (iii) adverse impacts on any underground mine, and (iv) change in the course, channel, or availability of ground or surface water outside the permit area;

# SMCRA

(D) require that all blasting operations be conducted by trained and competent persons as certified by the regulatory authority;

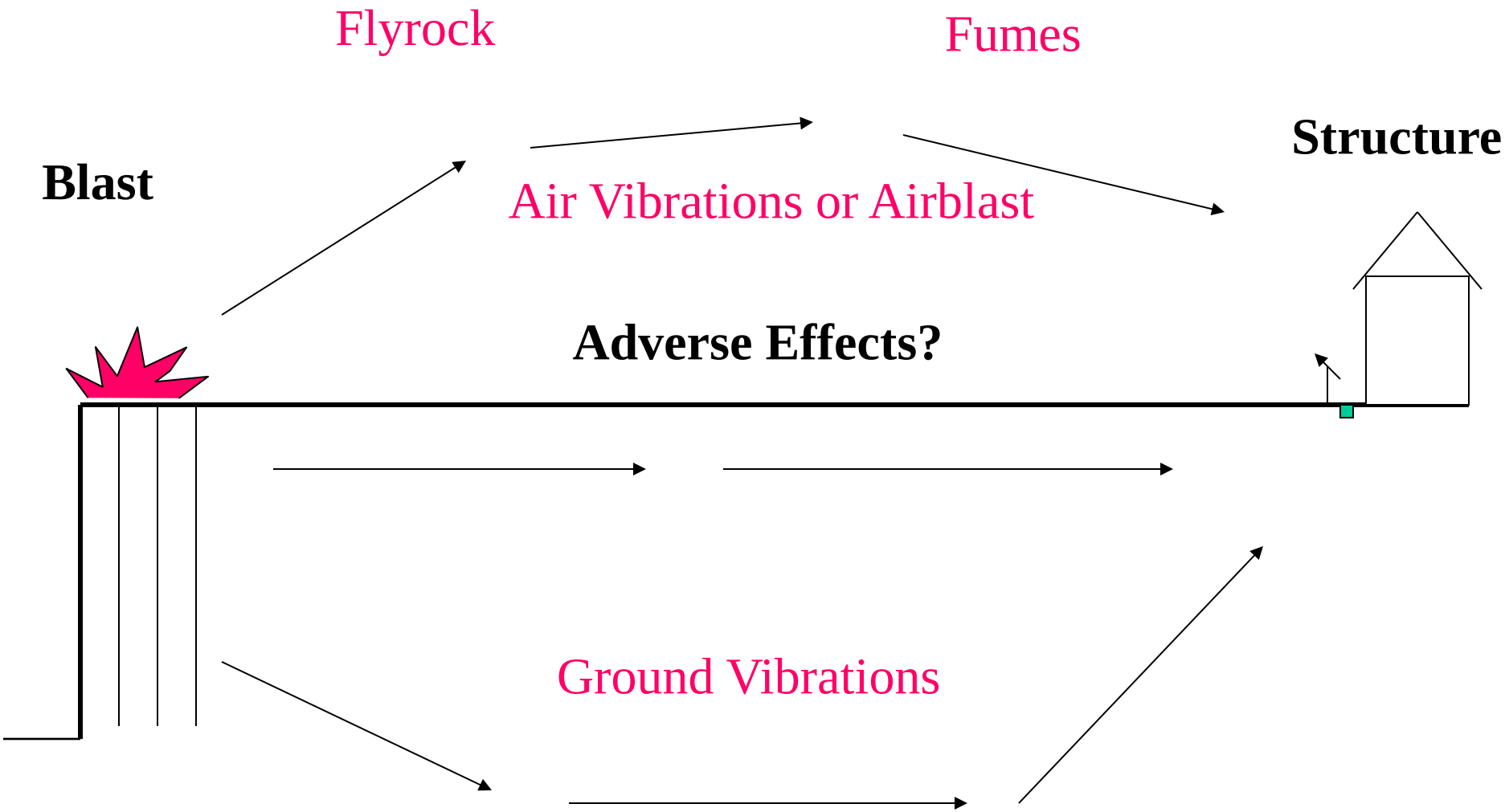
(E) provide that upon the request of a resident or owner of a man-made dwelling or structure within **one-half mile of any portion of the permitted area** the applicant or permittee shall conduct a **pre-blasting survey** of such structures and submit the survey to the regulatory authority and a copy to the resident or owner making the request. The area of the survey shall be decided by the regulatory authority and shall include such provisions as the Secretary shall promulgate.

# Use of Explosives Rules - 30 CFR

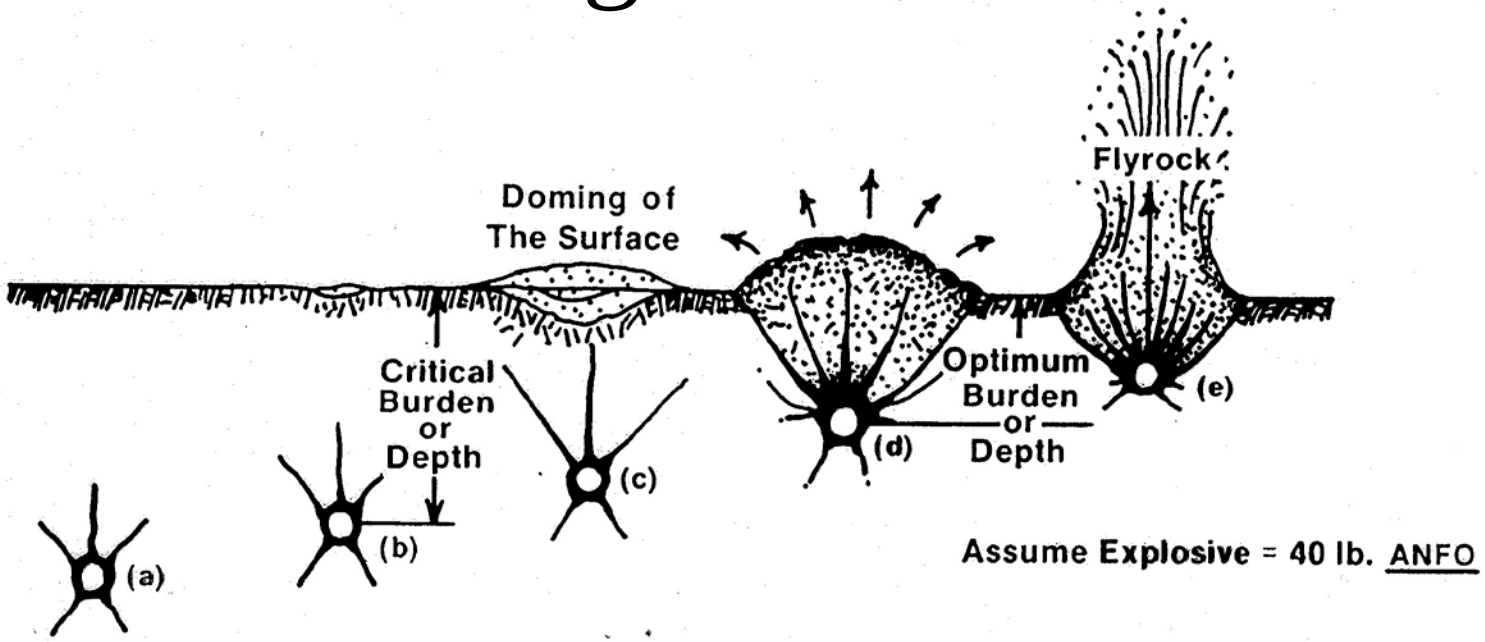
- Blast Plans (780.13)
- General requirements (816.61)
- Preblasting surveys (816.62)
- Blasting schedules (816.64)
- **Blasting signs, warnings, and access control** (816.66)
- Control of adverse effects (816.67)
- **Records of blasting operations (816.68)**
- Certification of blasters (850)

# The Setting – Mine and People

# Three Sciences



# Blasting Basics




(a) B = 15′

Completely contained, only failure is pulverisation near the charge and radial tensile failure running out from it.

(b) B = 12′

Start of surface failure. Burden not broken. Some doming of the surface.

(c) B = 9′

Surface and subsurface failure almost meet. There will be a shelf of unbroken rock between the two. Doming or surface bulging.

(d) B = 6′

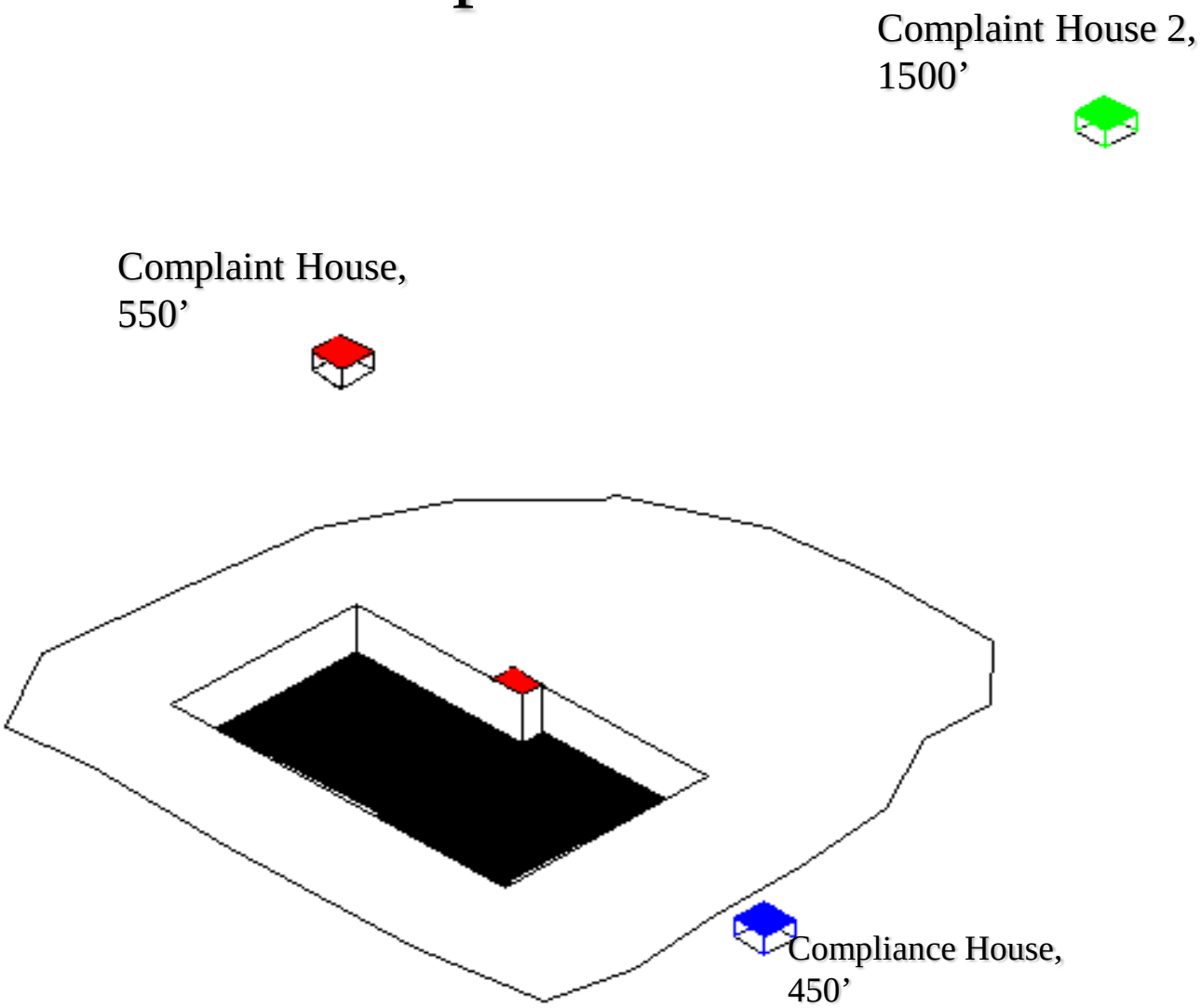
Full crater, burden completely broken out. Surface and subsurface failures run through to the surface.

(e) B = 3′

Full crater, lower volume than optimum fine fragmentation. Noise, flyrock, bowl shaped crater.

*Figure 7.17. Schematic of the Effect of Decreasing the Burden on Charges Fired in Rock.*

# Spatial Relationships



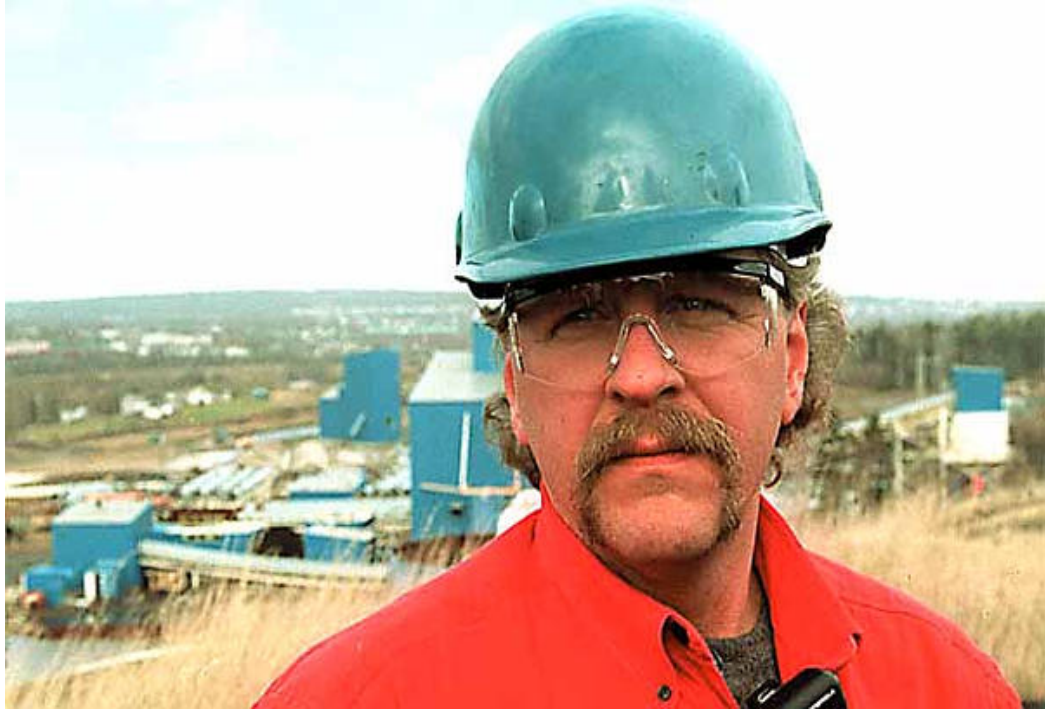
# Movie

"Dance of the Detonators"

- Multitude of blasts done safely
  - Construction
  - Quarries
  - Coal mining

- Anticipate the Adverse Effects
  - Flyrock
  - Ground Vibrations
  - Airblast

# Blaster’s Focus



# Geology Considerations

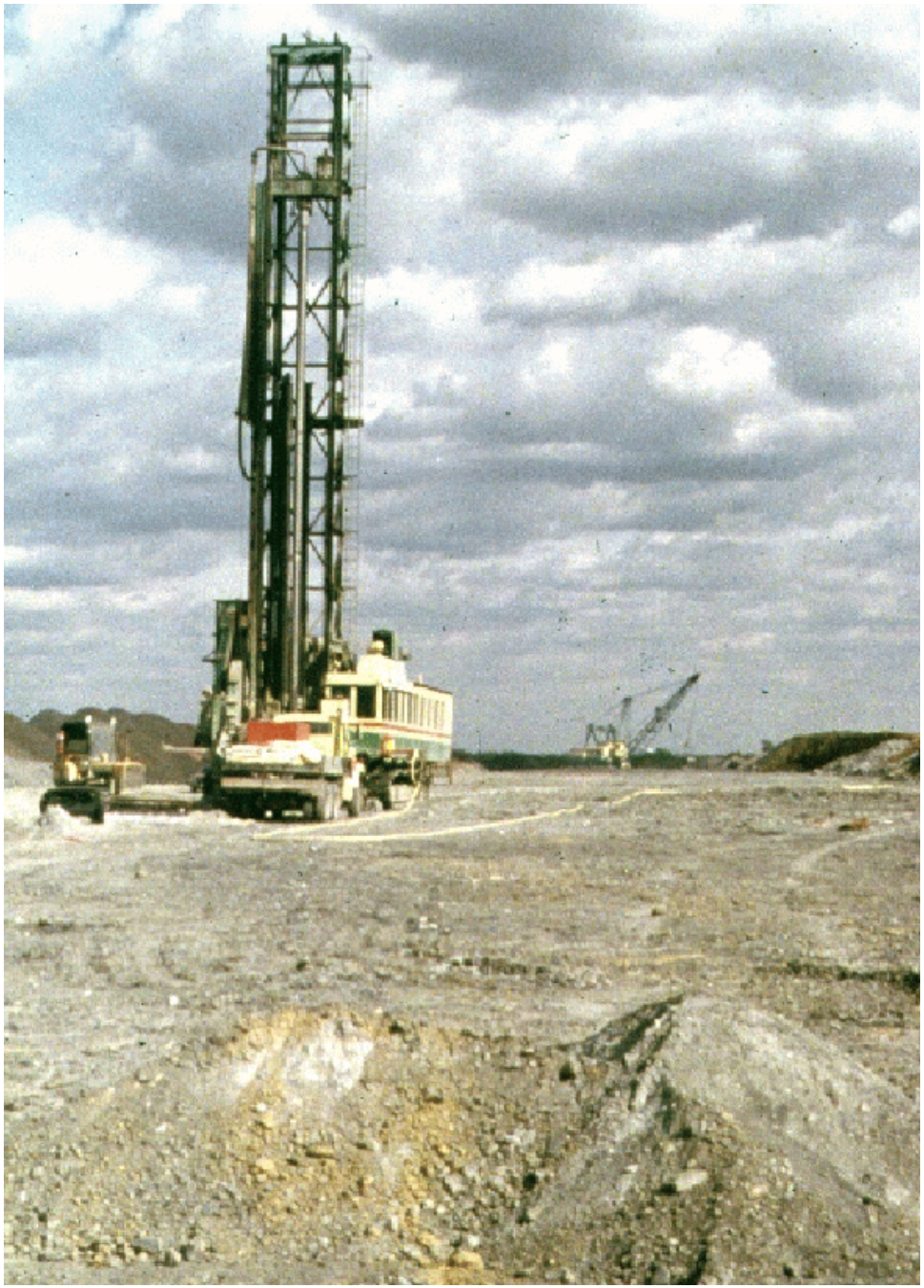
# Unusual Geology

# Dragline

# Truck and Shovel

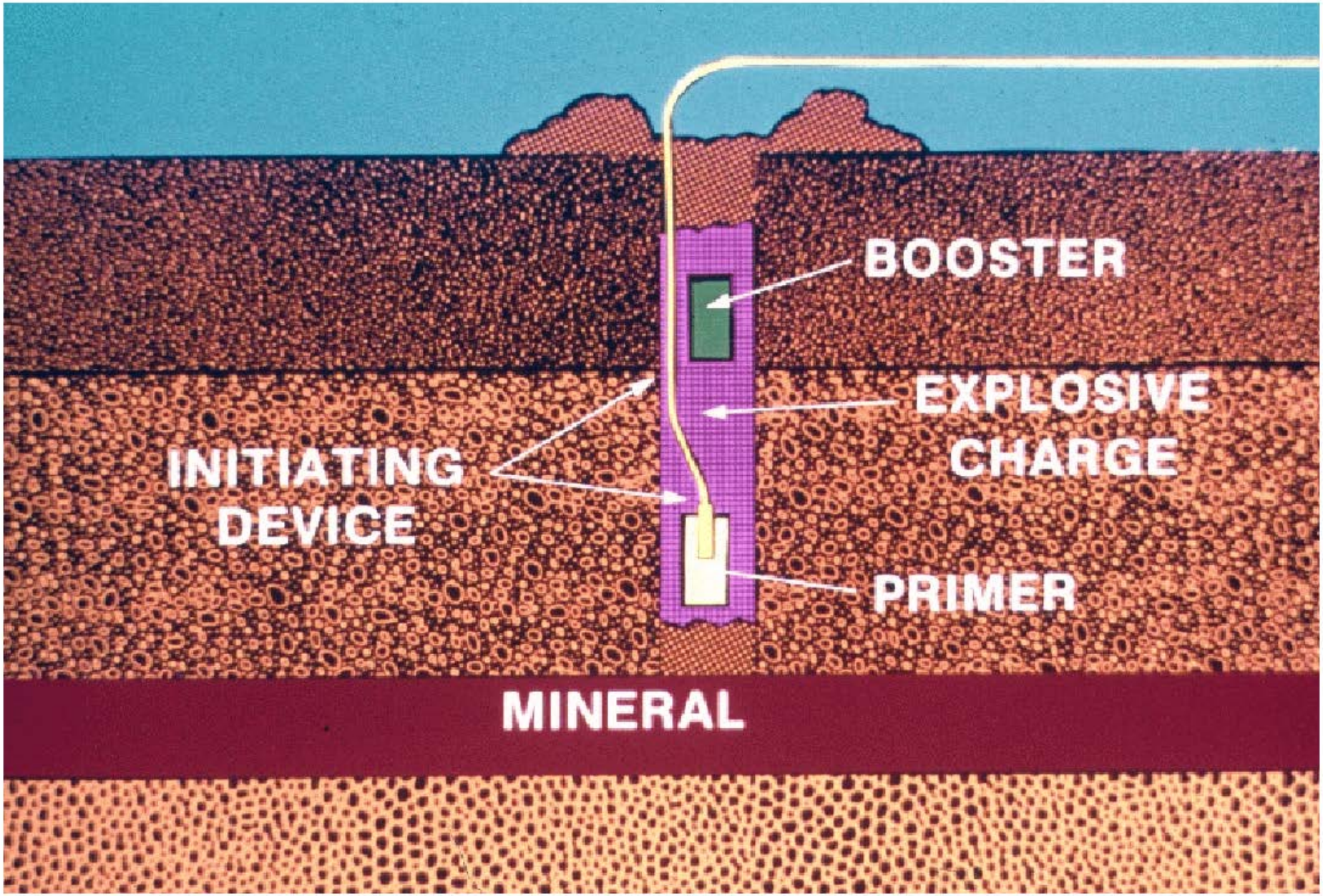
# Bulldozer

# Rotary Drills



# Drill holes and Cuttings

# Blast Hole Components

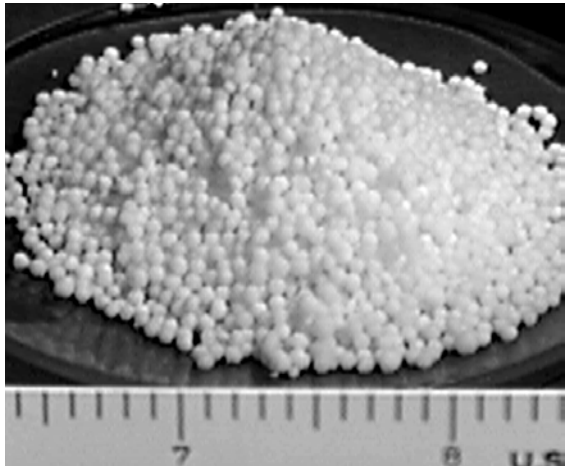


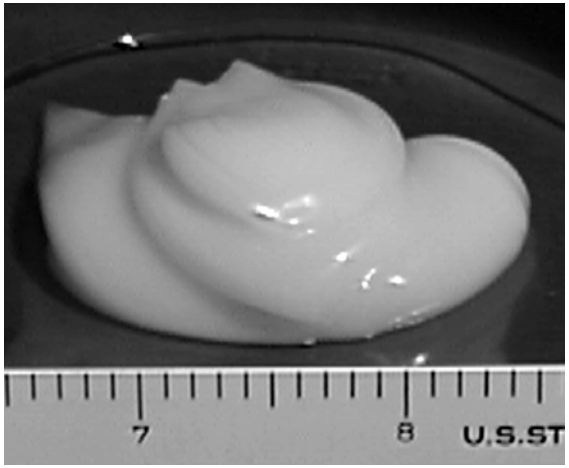
# Bulk Loading

# Bag Products – 50#

# AN-Based Products

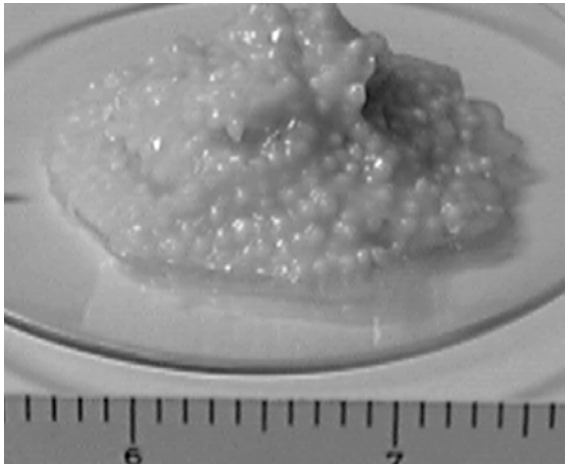
ANFO





Emulsion *Matrix*

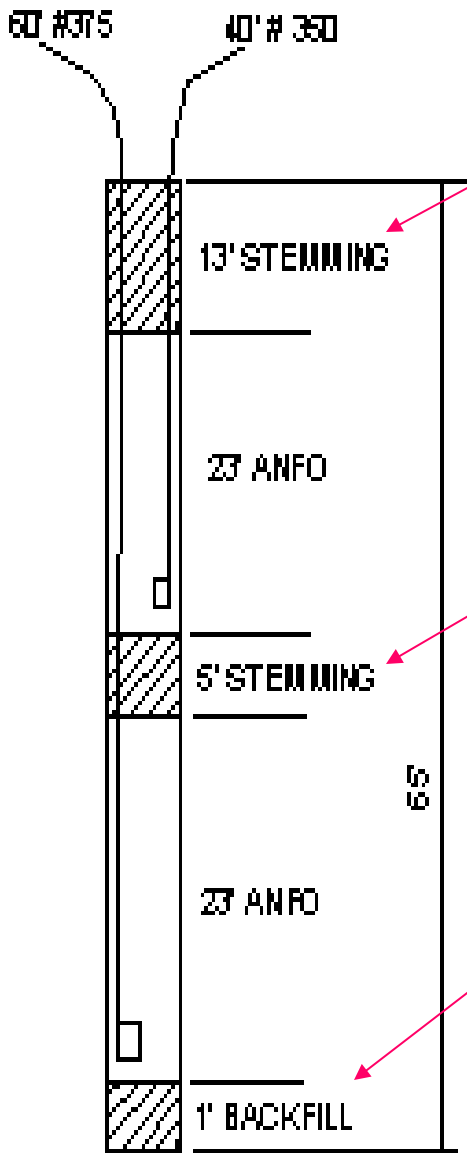
Augured Blends



Pumpable Blends

# Primer = Booster + Detonator

# Decked Holes




- Collar Stemming

  Inert material from top of uppermost explosive charge to the surface

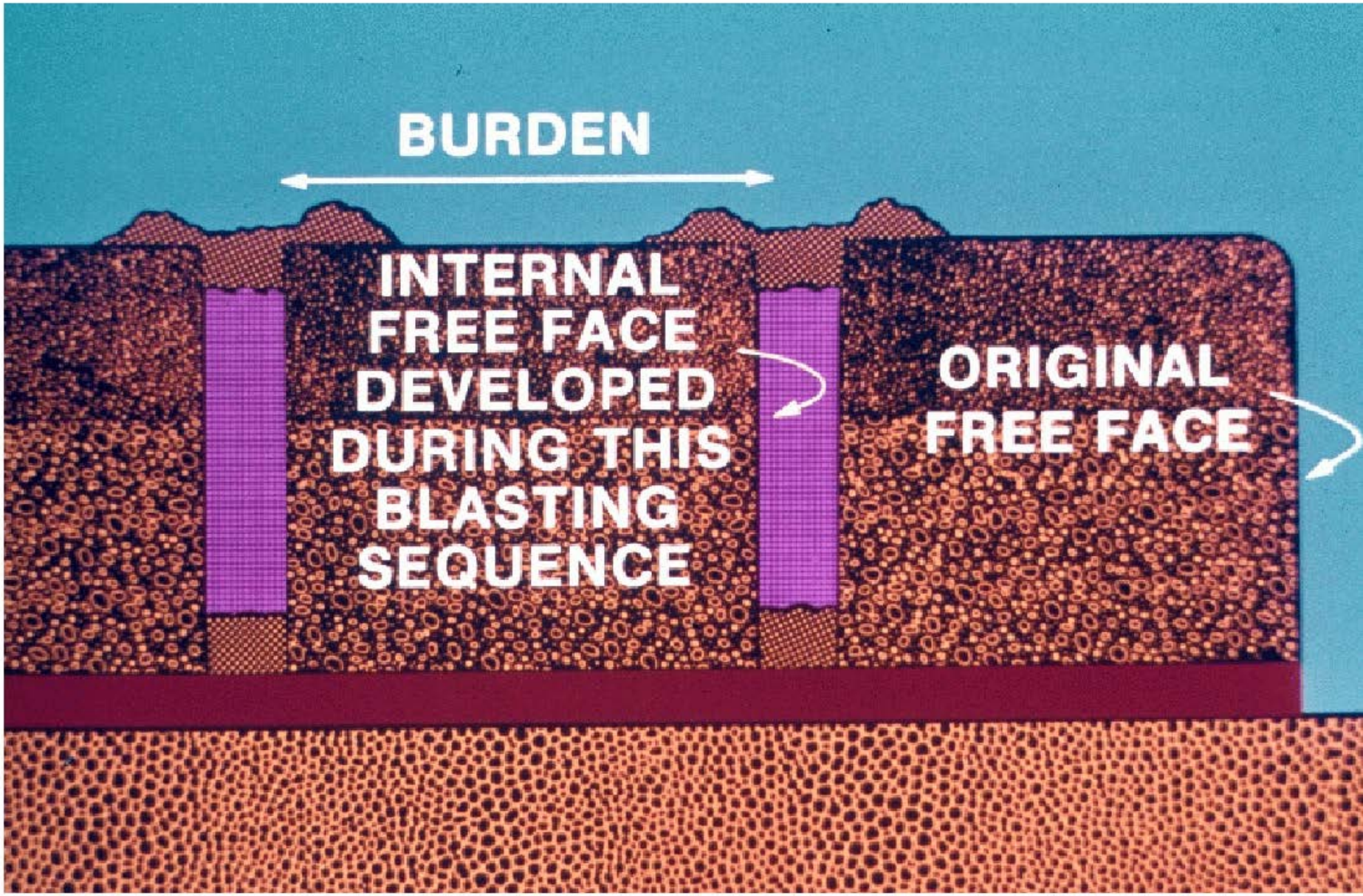
- Interdecking

  Inert material between explosives charges

- Backfilling

  Inert material between explosives charge and the coal

# Holes are designed to focus energy laterally.



# Blast Hole Parameters

- **B = BURDEN (ft)**
- **S = SPACING (ft)**
- **T = STEMMING (ft)**
- **H = HOLE DEPTH (ft)**
- **$T_d$ = DECKING (ft)**
- **J = SUB DRILL *(ft)**
- **F = BACKFILL (ft)**

***Not used when shot directly above coal**

# BLAST DESIGN

# RULES OF THUMB

**HOLE DIAMETER (d)** = hole depth (H) divided by 5 to 10.

$d(in) = H(ft) / 5$ to $H(ft) / 10$ (Usually not an option)

**BURDEN (B)** = 2 to 3 times the diameter.

$B(ft) = 2 \times d(in)$ to $3 \times d(in)$ (Typically $2.5 \times d$)

**SPACING (S)** = 1 to 2 times the burden.

$S(ft) = 1 \times B(ft)$ to $2 \times B(ft)$ (Typically $1.5 \times B$)

**STEMMING (T)** = 0.5 to 1.0 times the burden.

$T(ft) = 0.5 \times B(ft)$ to $1.0 \times B(ft)$ (Typically $0.7 \times B$)

**POWDER COLUMN (PC)** = hole depth minus stemming.

$PC(ft) = H(ft) - T(ft)$

**LOADING DENSITY (LD)** = 0.3405 times the explosive density times the hole diameter squared.

$LD(lb/ft) = 0.3405 \times density(gm/cc) \times d^2(in)$ (or Mfg design guide)

**CHARGE WEIGHT (CW)** = powder column times the loading density.

$CW(lb) = PC(ft) \times LD(lb/ft)$

**POWDER FACTOR (PF)** = powder per hole divided by rock volume per hole.

$PF(lb/yd^3) = CW(lb) / (B(ft) \times S(ft) \times H(ft) / 27)$

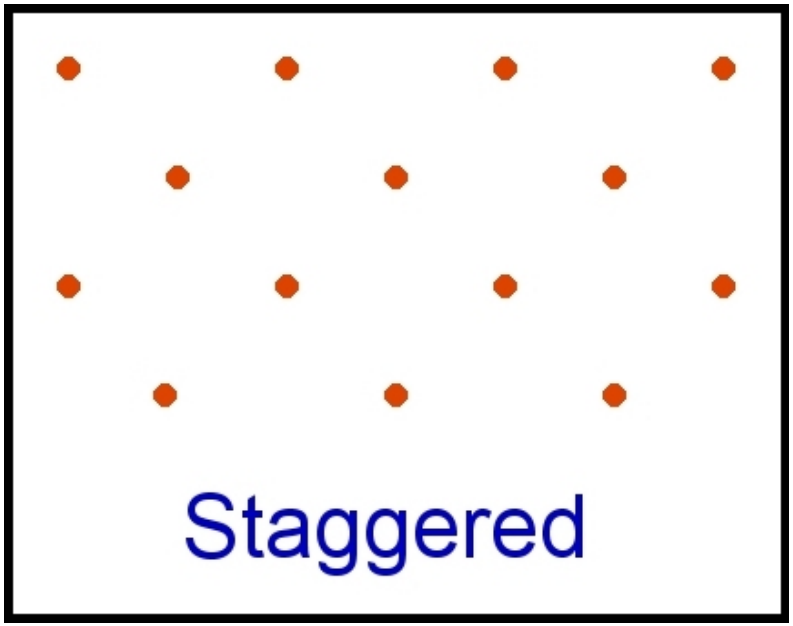
**SCALED DISTANCE (SD)** = Distance to structure divided by square root of the charge weight.

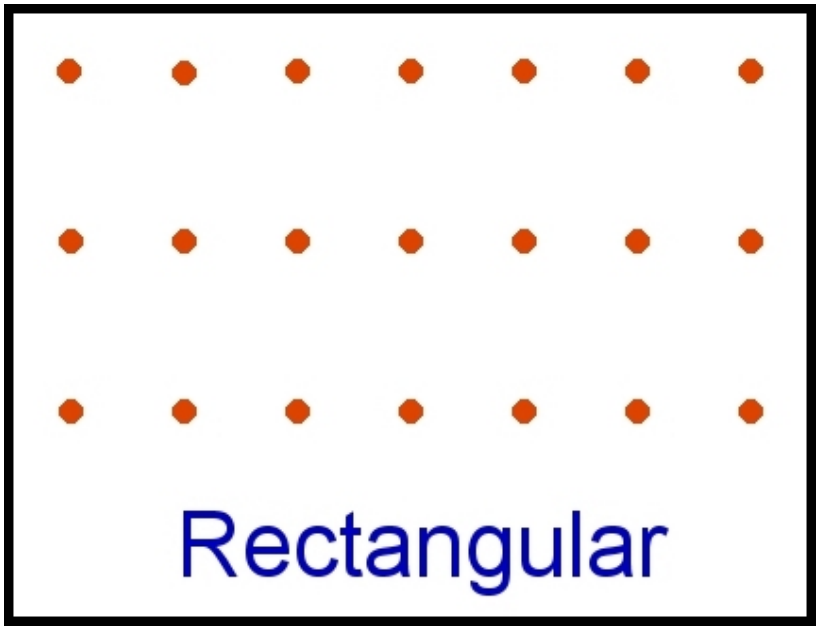
$SD(ft/lb^{1/2}) = distance(ft) / CW^{1/2}(lb^{1/2})$ (Greater than 55)

**PEAK PARTICLE VELOCITY (PPV)** = 438 times scaled distance to the -1.52 power.

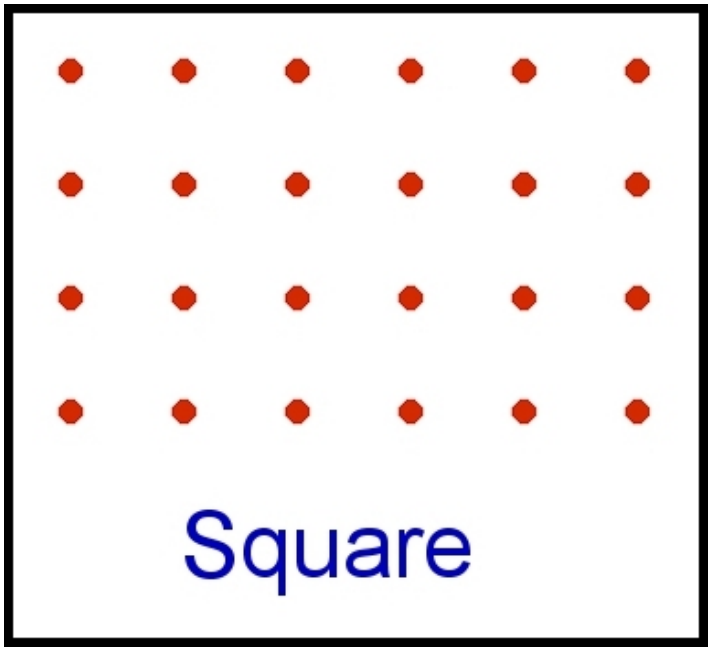
$PPV(in/s) = 438 \times (SD)^{-1.52}$ (Maximum expected)

# Drill Patterns
# and
# Initiation Sequence

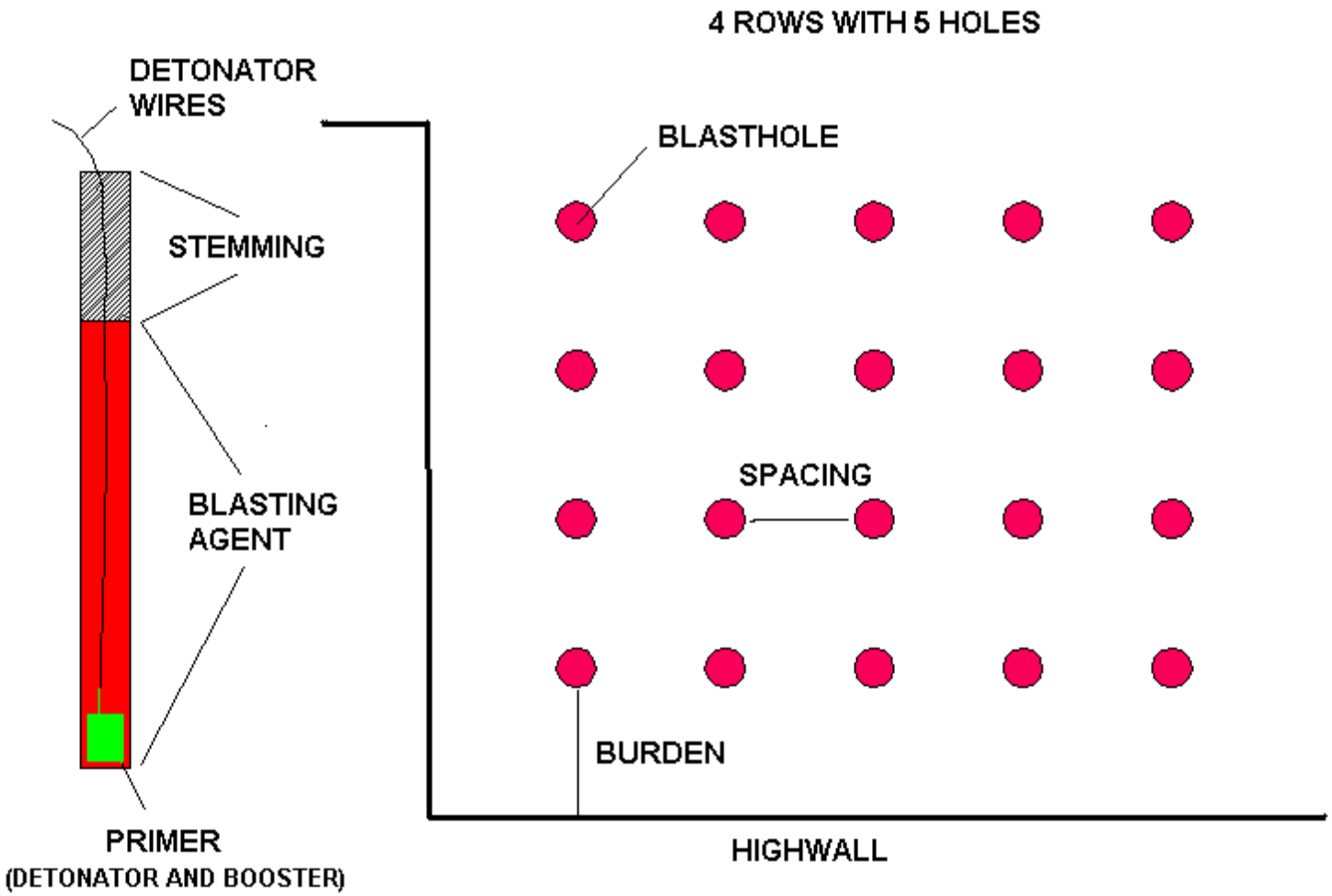



Drilling Layout



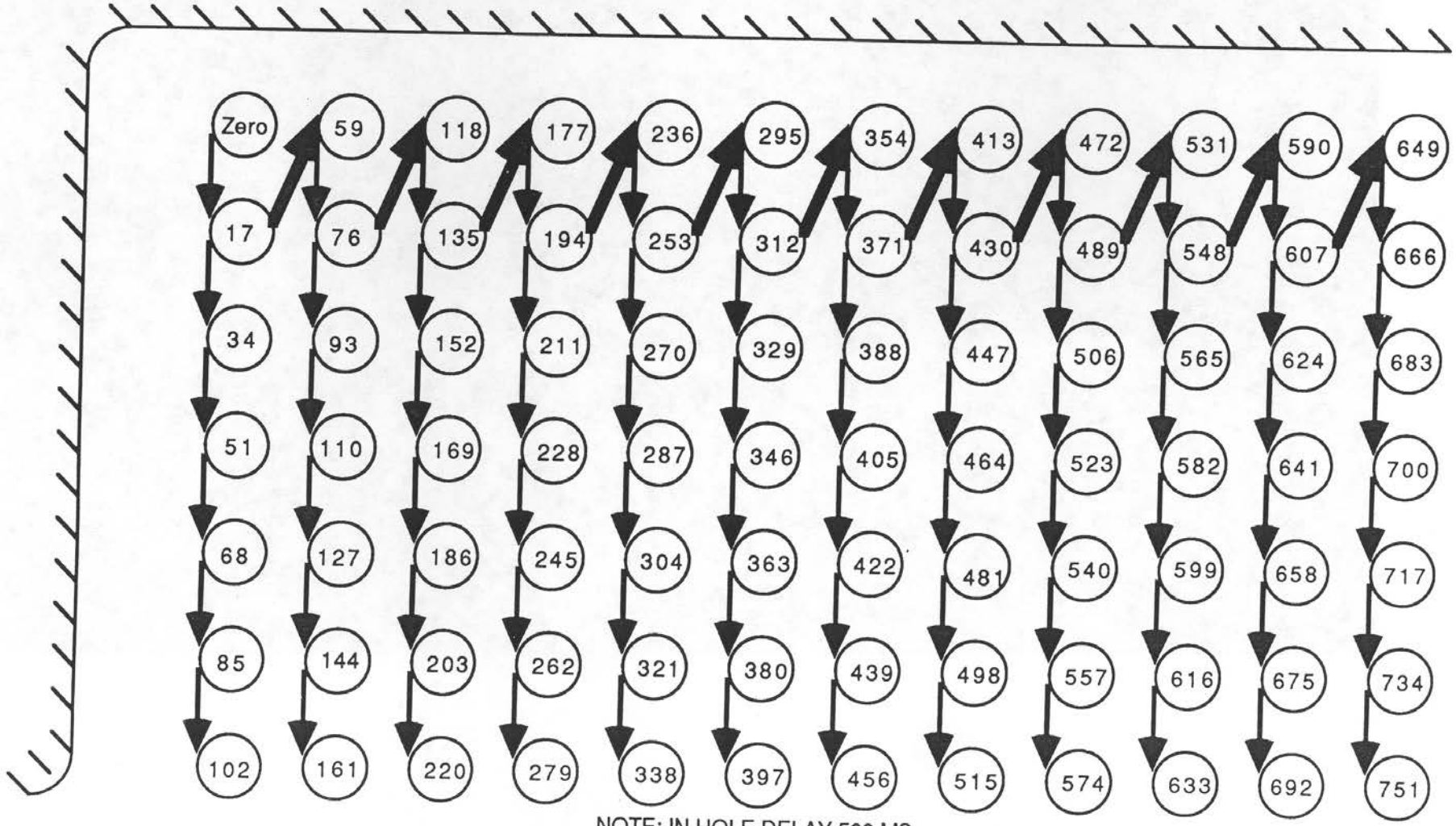
# Blast Design Patterns



**BLASTMASTER® T&D (Trunkline & Delay)**
**7 HOLES/ROW, ∞ NUMBER OF ROWS**
**59 MS HOLE-HOLE, 17 MS ROW-ROW**
**ONE HOLE/DELAY**

→ = 17 MS
➡ = 42 MS

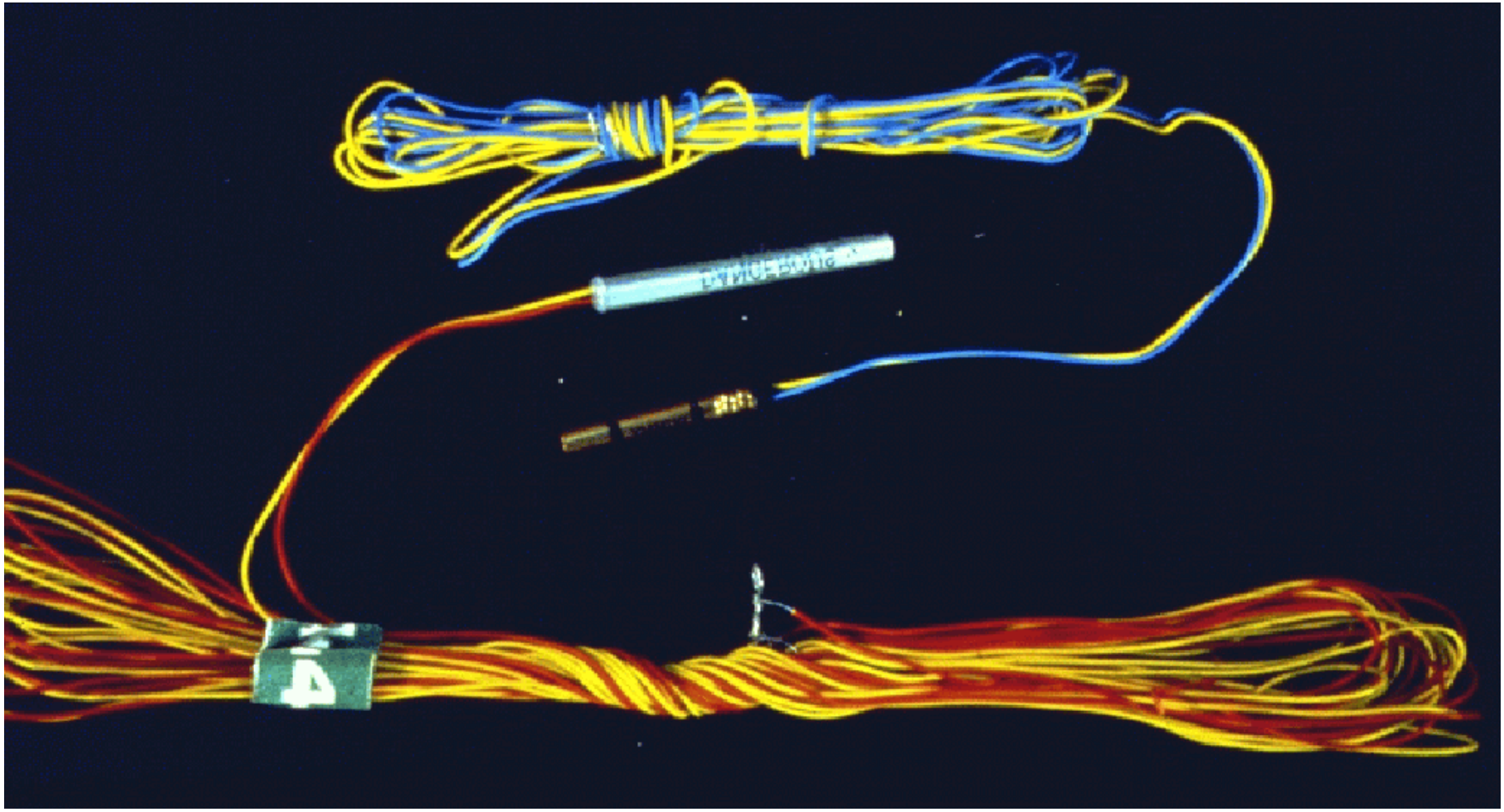
# Connecting Holes




NOTE: IN HOLE DELAY 500 MS

# Electric Distribution Network

## Electric Caps



# NON-EL Distribution Network

## DETONATING CORD

# PETN – 6 to 50 grains per foot

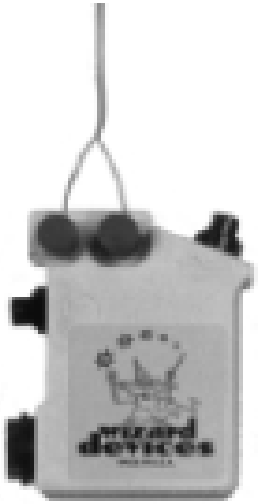
# NON-EL Distribution Network

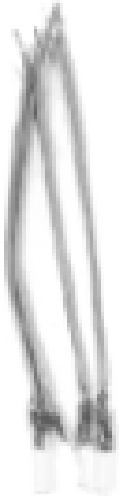
## SHOCKTUBE

Primadet
100FT/PI
WARNING
250
17
350

# Lead-in Line

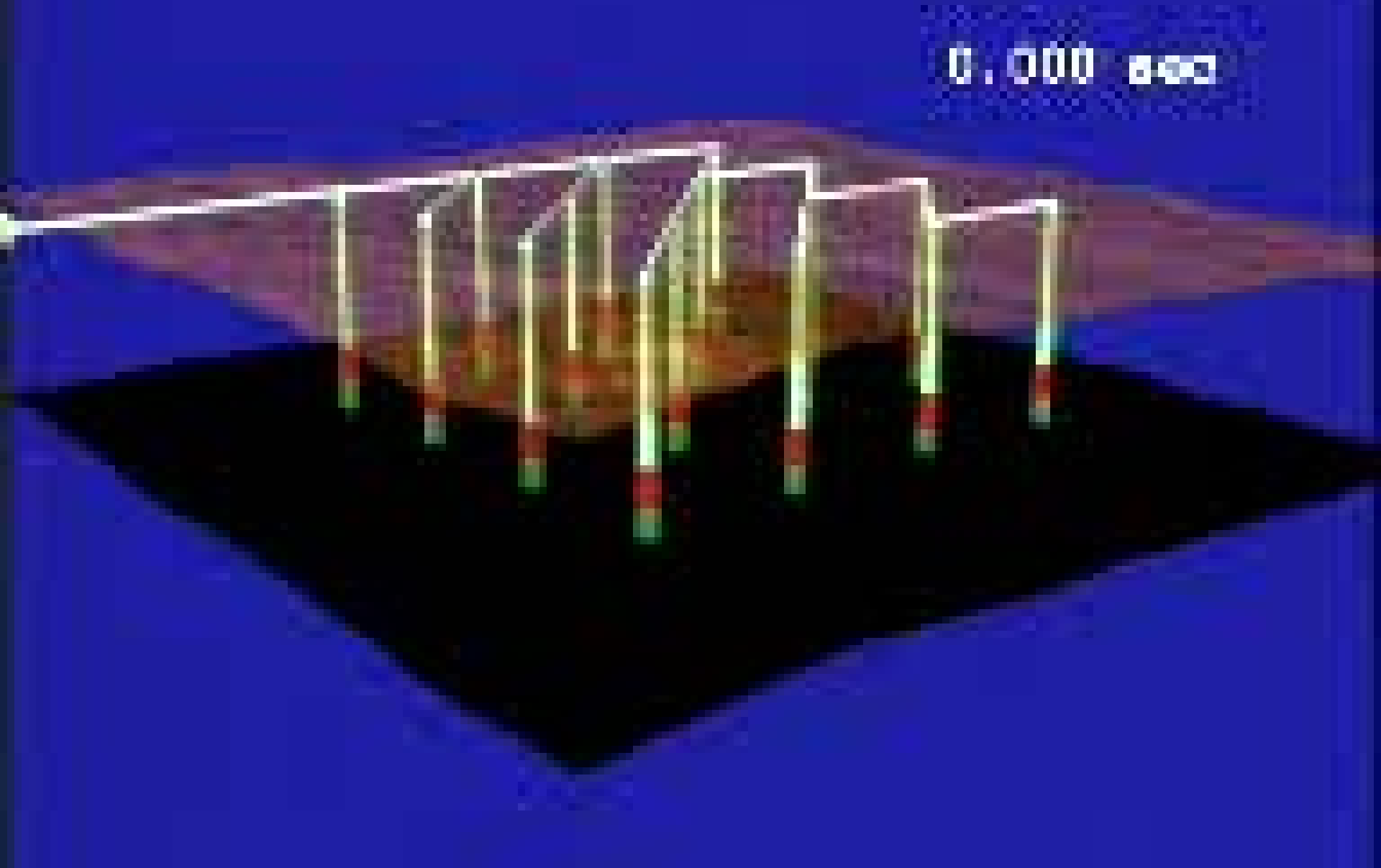
# Blasting Machines

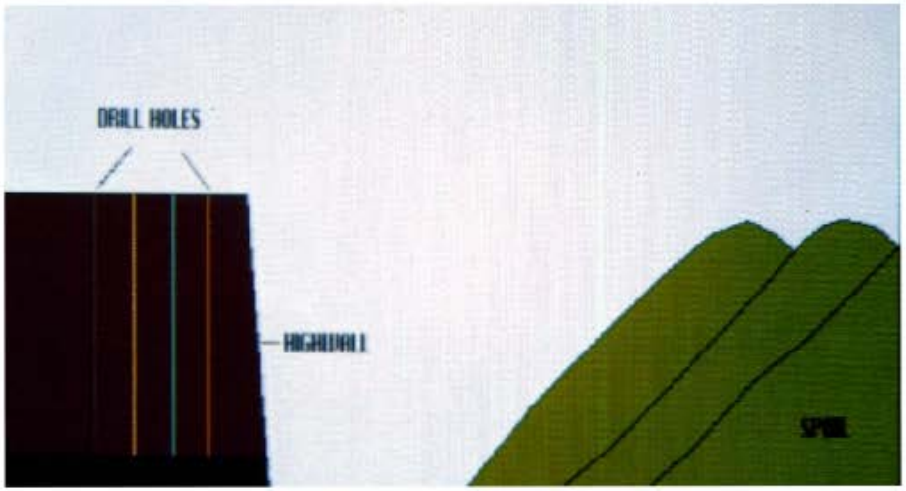


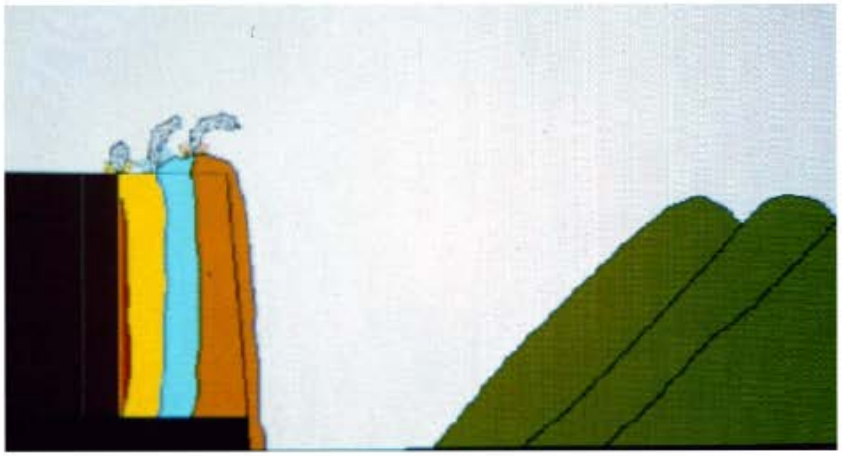



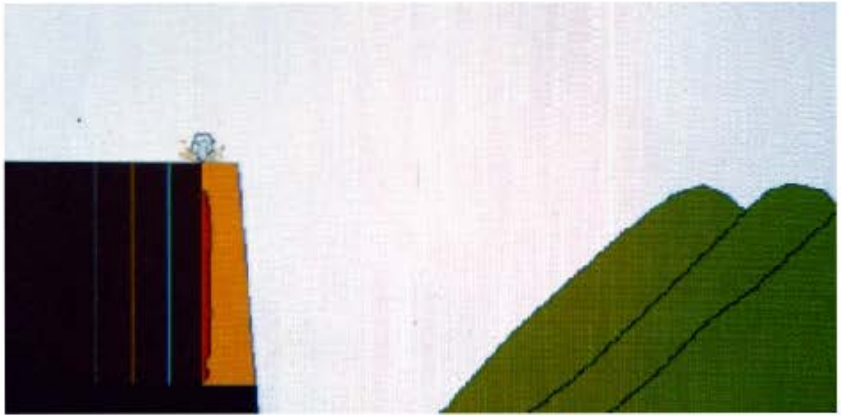
# Detonation

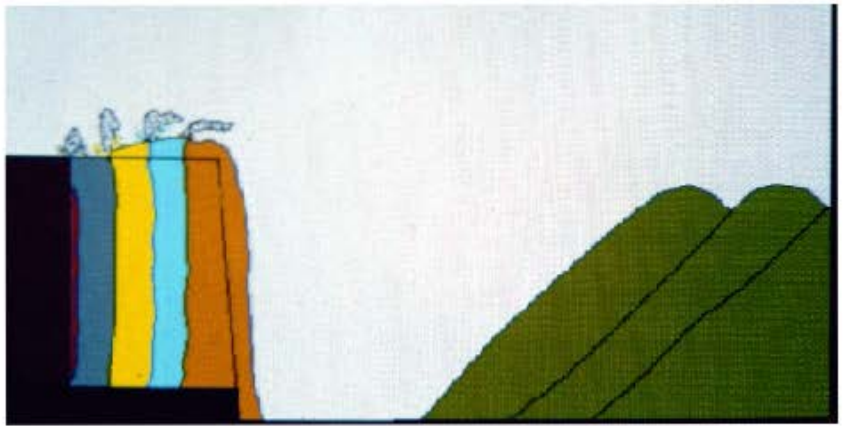
# Surface and Downhole Delays

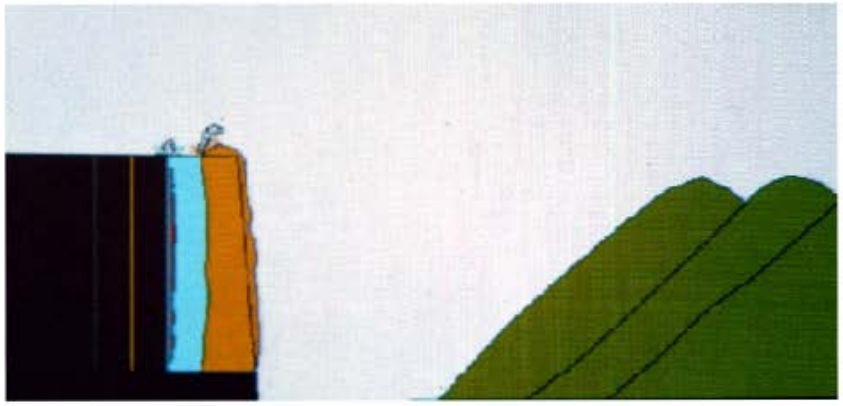



DRILL HOLES
HIGHWALL

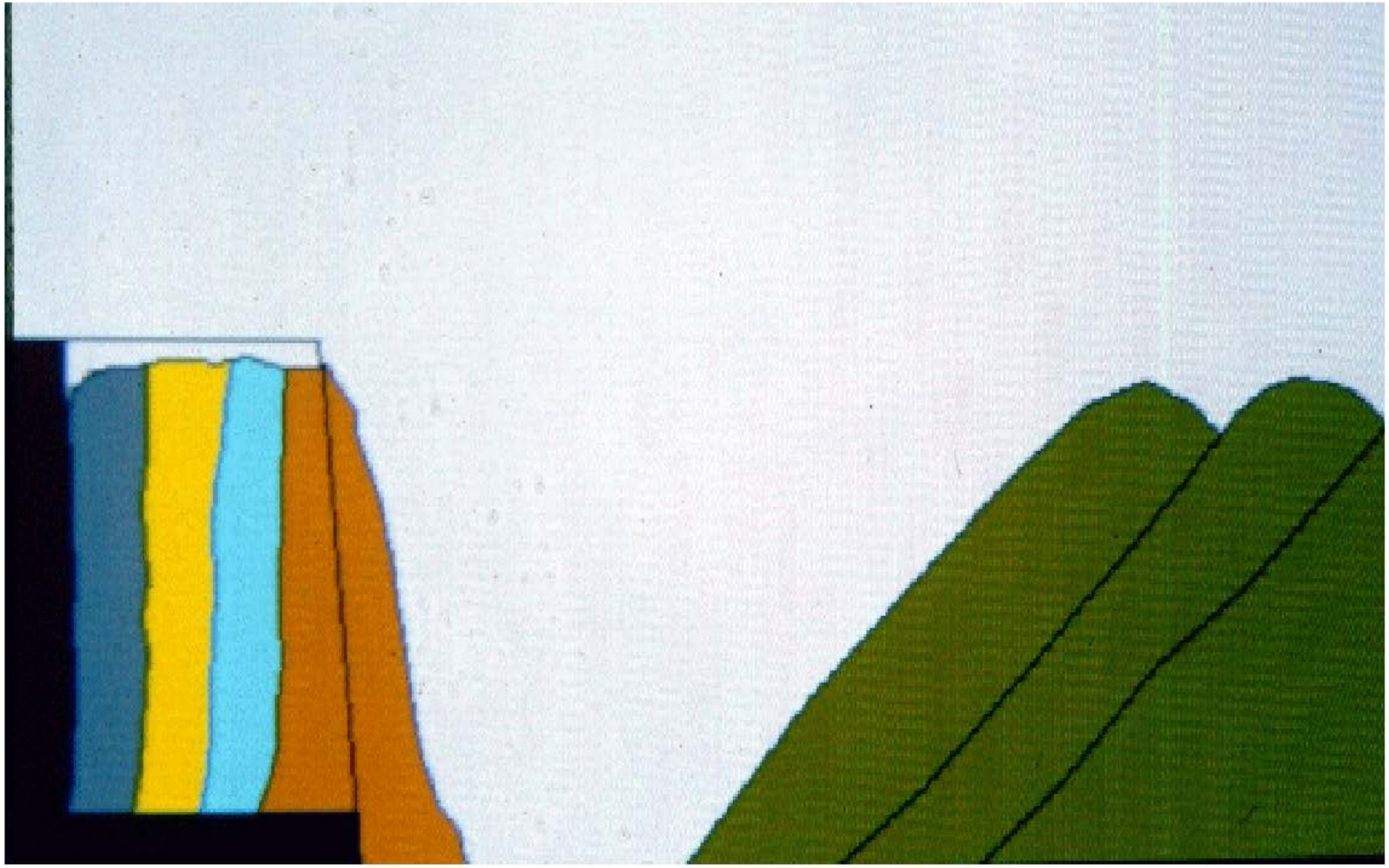


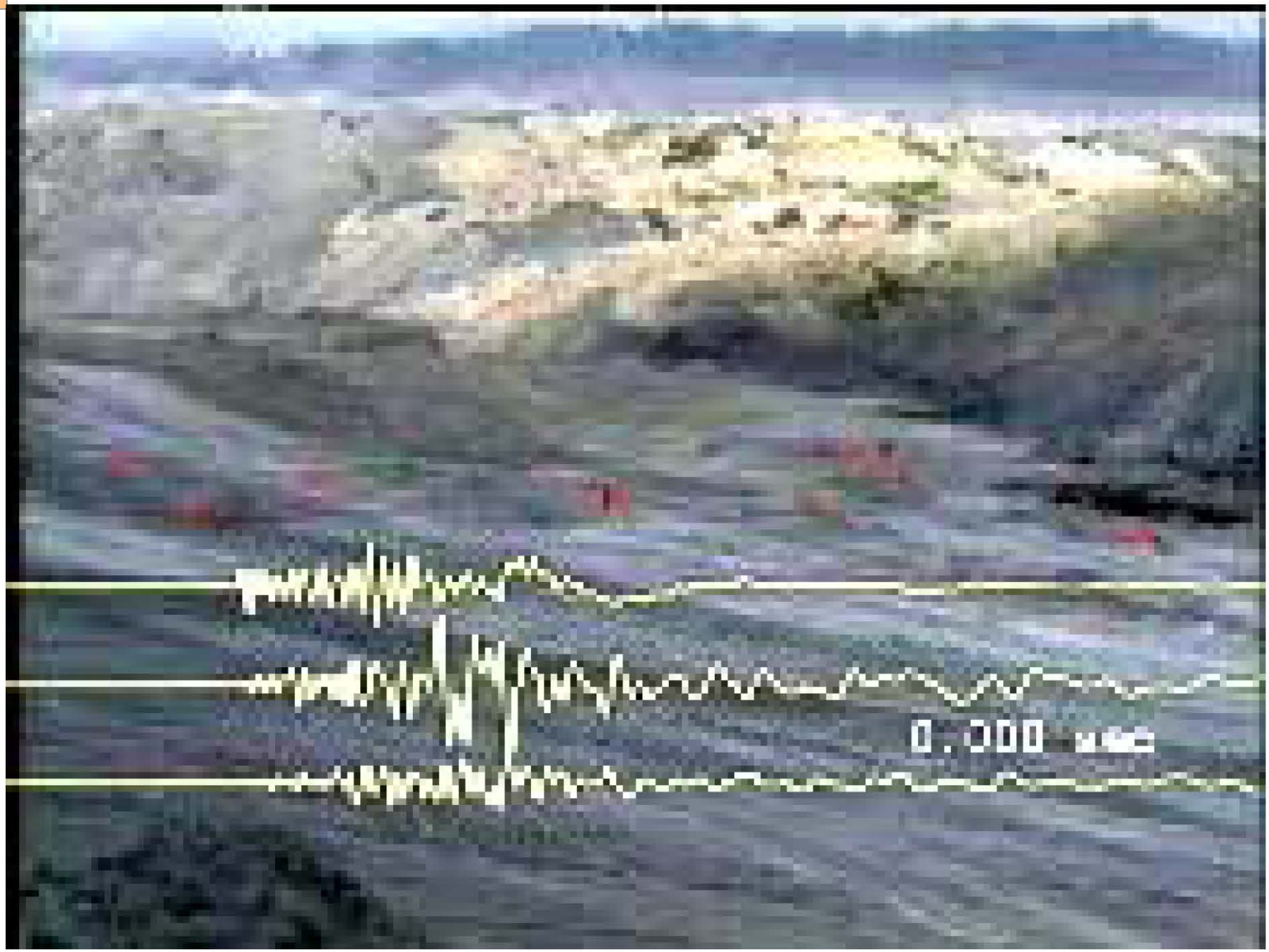






# Conventional Blast

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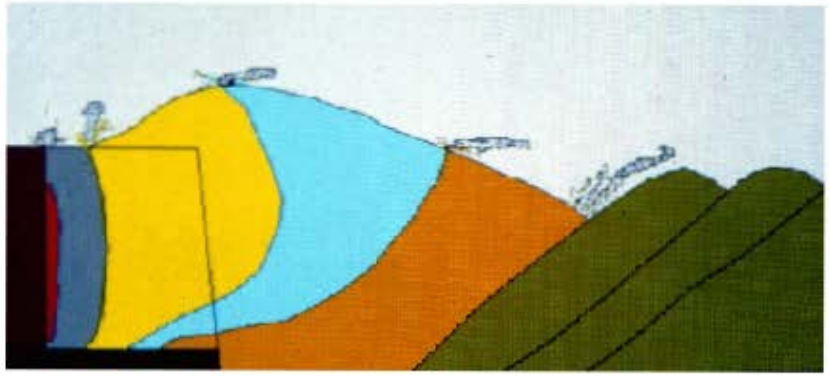
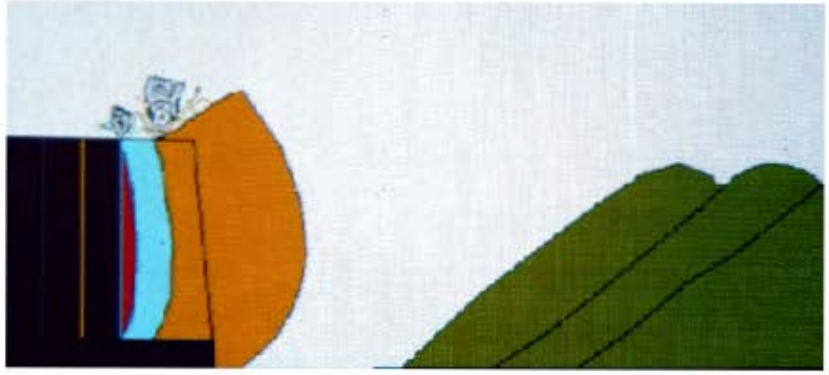
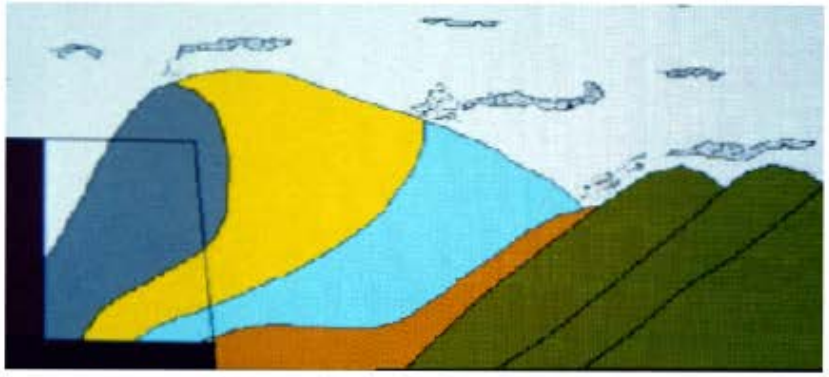
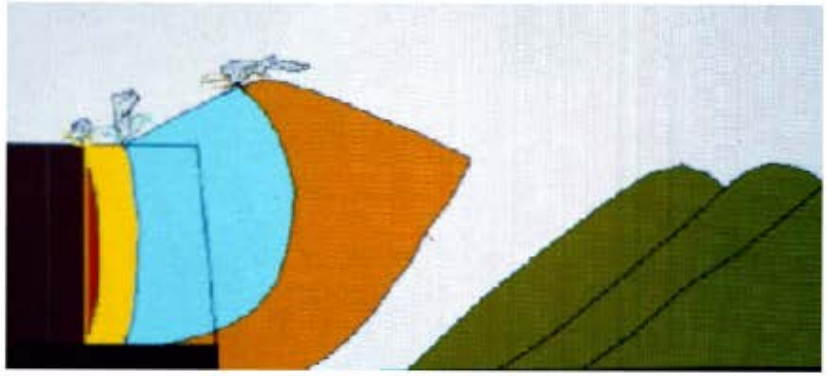
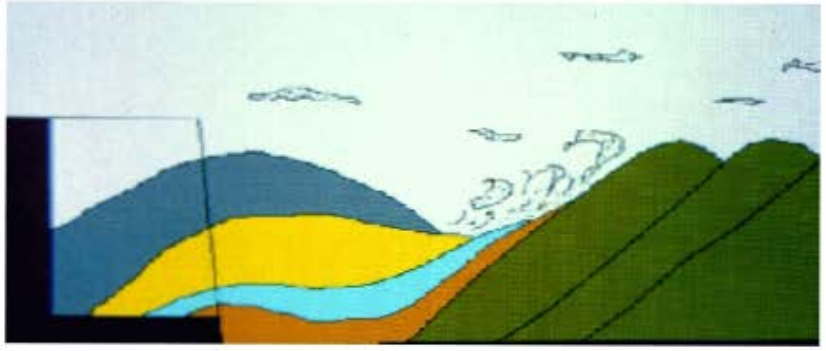


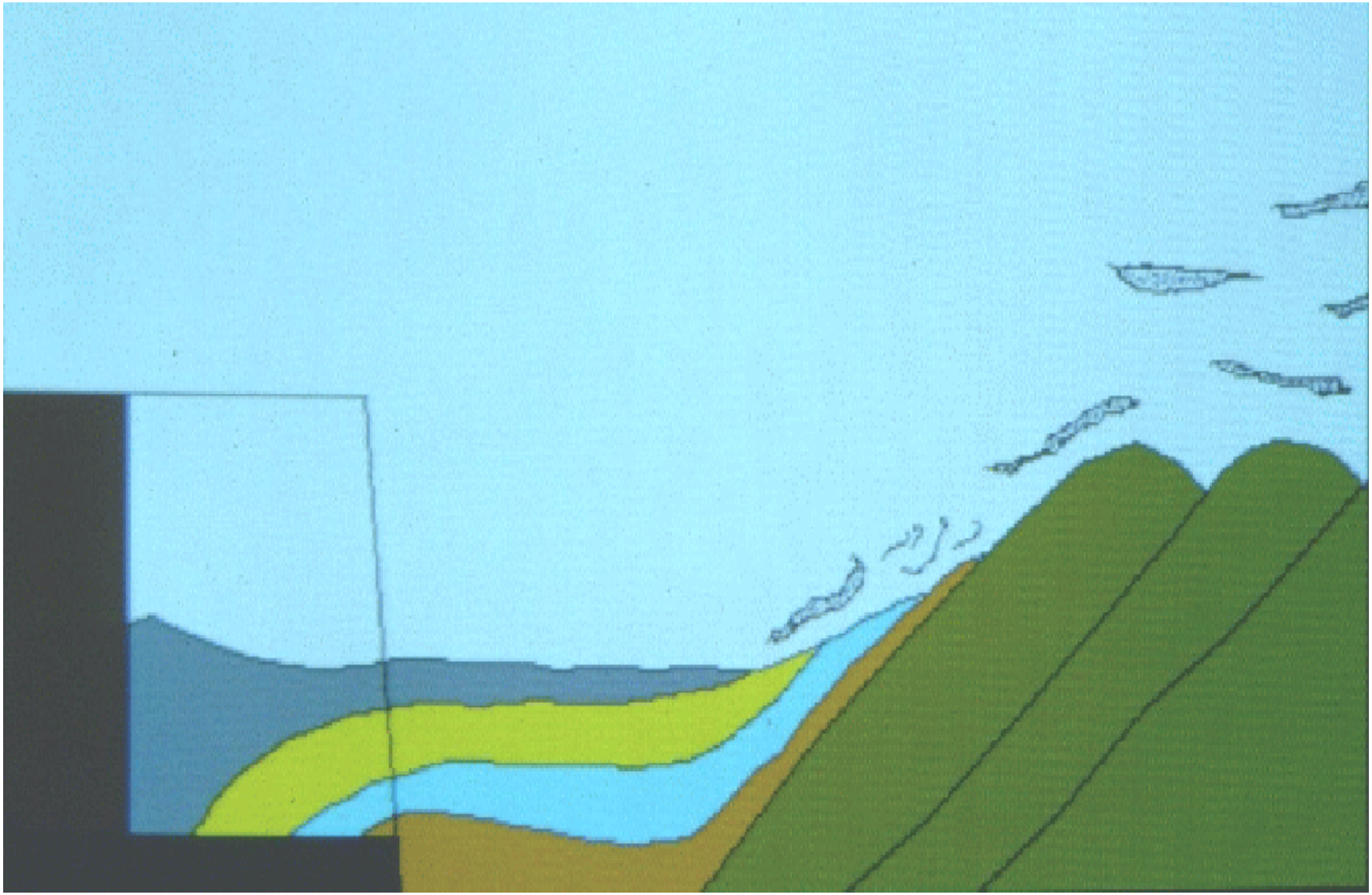








# Cast Blast



29S2-HW

8th May 2002

# Parting Blast

# Coal Blast

# Example… Good or bad?

# Adverse Effects

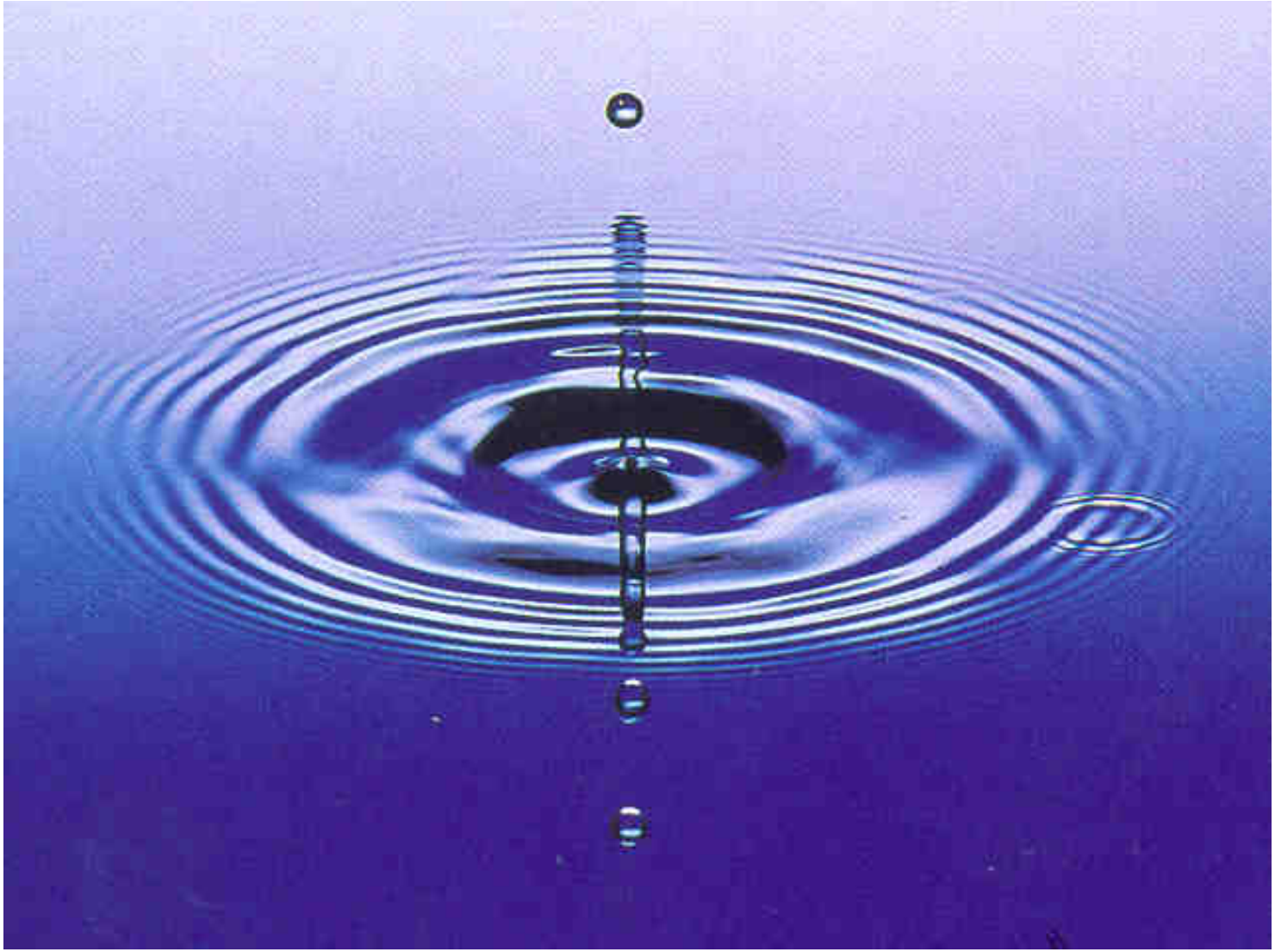
# Flyrock

- Beyond the permit area
- Beyond the blast area
- > ½ the distance to a house

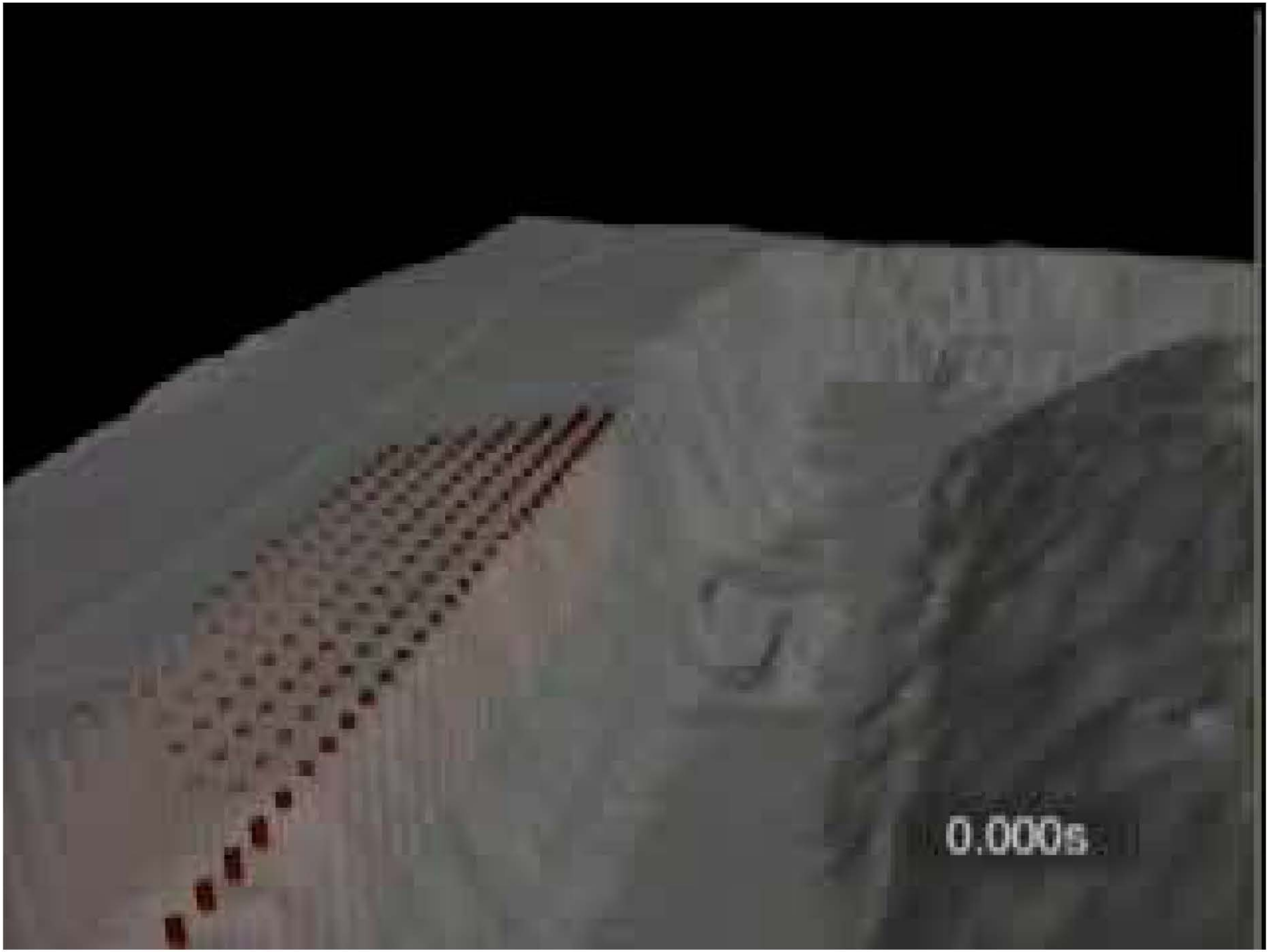
# Flyrock Injury

# Flyrock Property Damage

# Vibrations – Ground and Air



# Blasting Seismographs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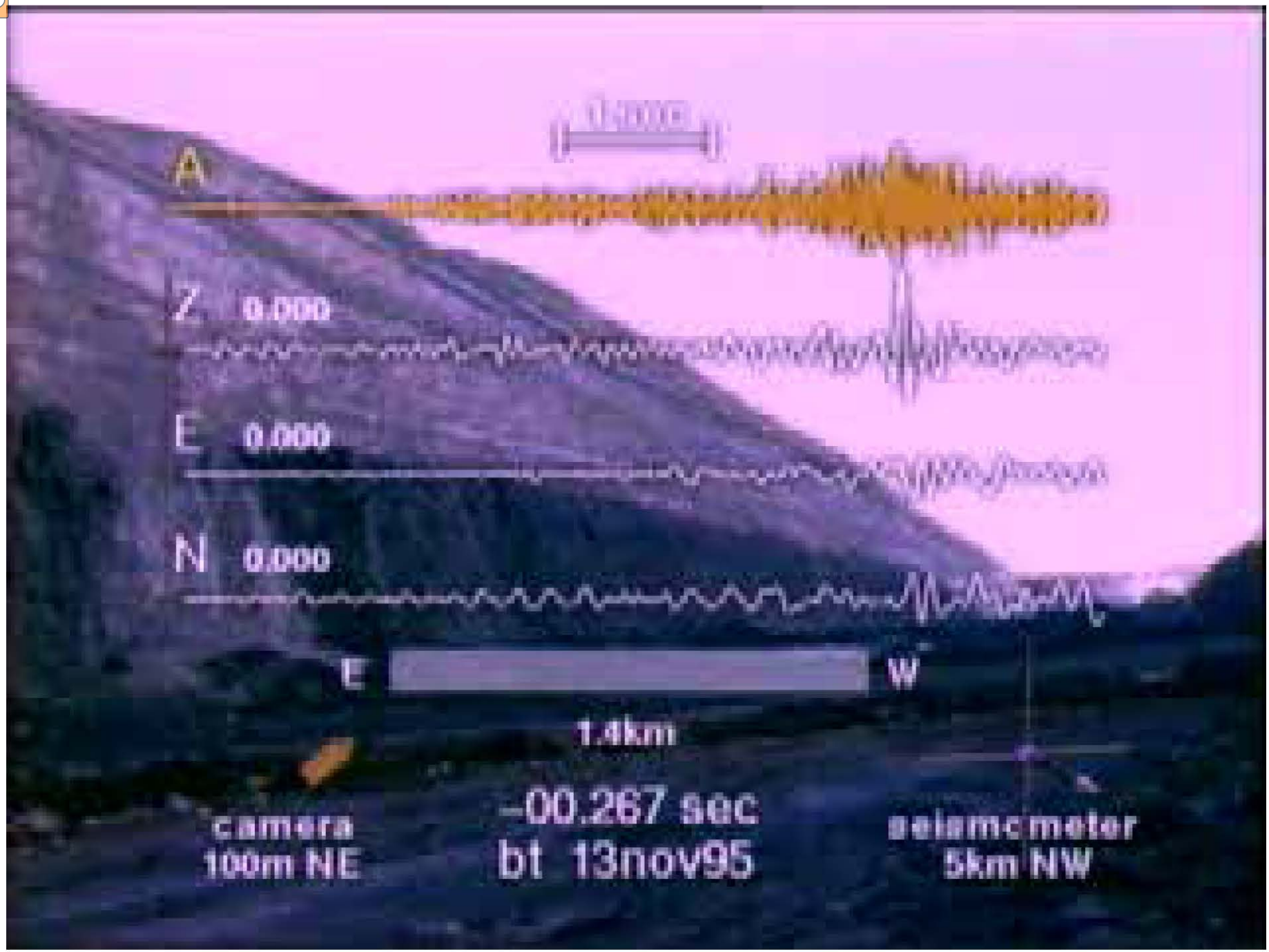

A
Z 0.000
E 0.000
N 0.000
E
W
1.4km
camera
100m NE
-00.267 sec
bt 13nov95
seismometer
5km NW

** SAFEGUARD SEISMIC UNIT 2000DK **
SN: 2243

DATE: 09/12/95 TIME: 15:18:06
Event: 009 Recording Time: 10
Client: ROBERTSON
Operation: BUCKEYE IND. MINING CO.
SSU Location: ROBERTSON YARD
Distance to blast: 1385
Operator: M.MANN/ODNR
Comments:
Trigger Level: .05 IN/SEC

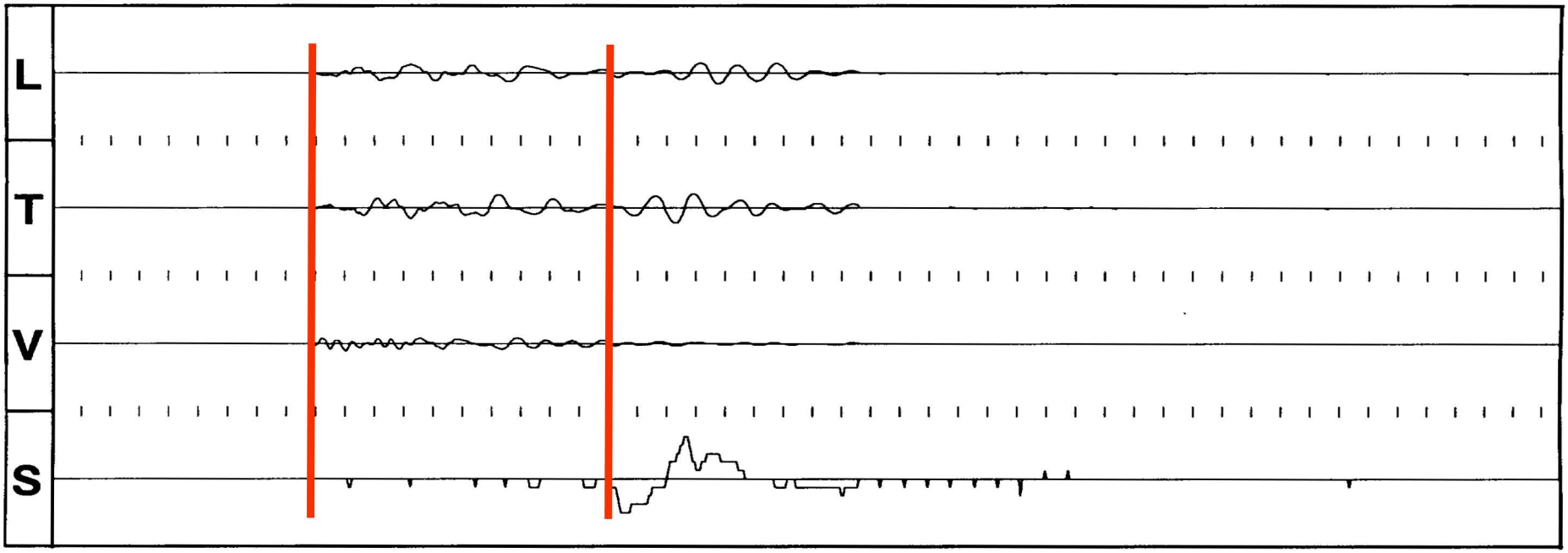
Summary

| | L | T | V |
|---|---|---|---|
| PPV (in/sec) | 0.10 | 0.14 | 0.07 |
| PD (in x.001) | 2.39 | 2.97 | 1.38 |
| PPA (g) | .02 | .02 | .02 |
| FREQ (Hz) | 8.0 | 7.6 | 16.6 |

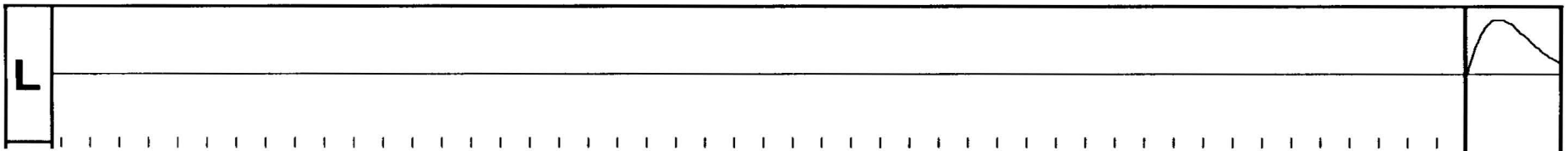
RESULTANT PPV (in/sec): 0.15
PEAK AIR PRESSURE: (dB) 114
(psi) 0.00145

VELOCITY WAVEFORM GRAPH SCALE
TIME = 100 MSEC PER MARK
SEISMIC = +/- .64 IN/SEC
SOUND = +/- 0.00232 PSI

SHAKETABLE CALIBRATED: 06/20/95
By GeoSonics, Inc.
Box 779, Warrendale, PA 15095 U.S.A.
TEL: 412.934.2900 FAX: 412.934.2999



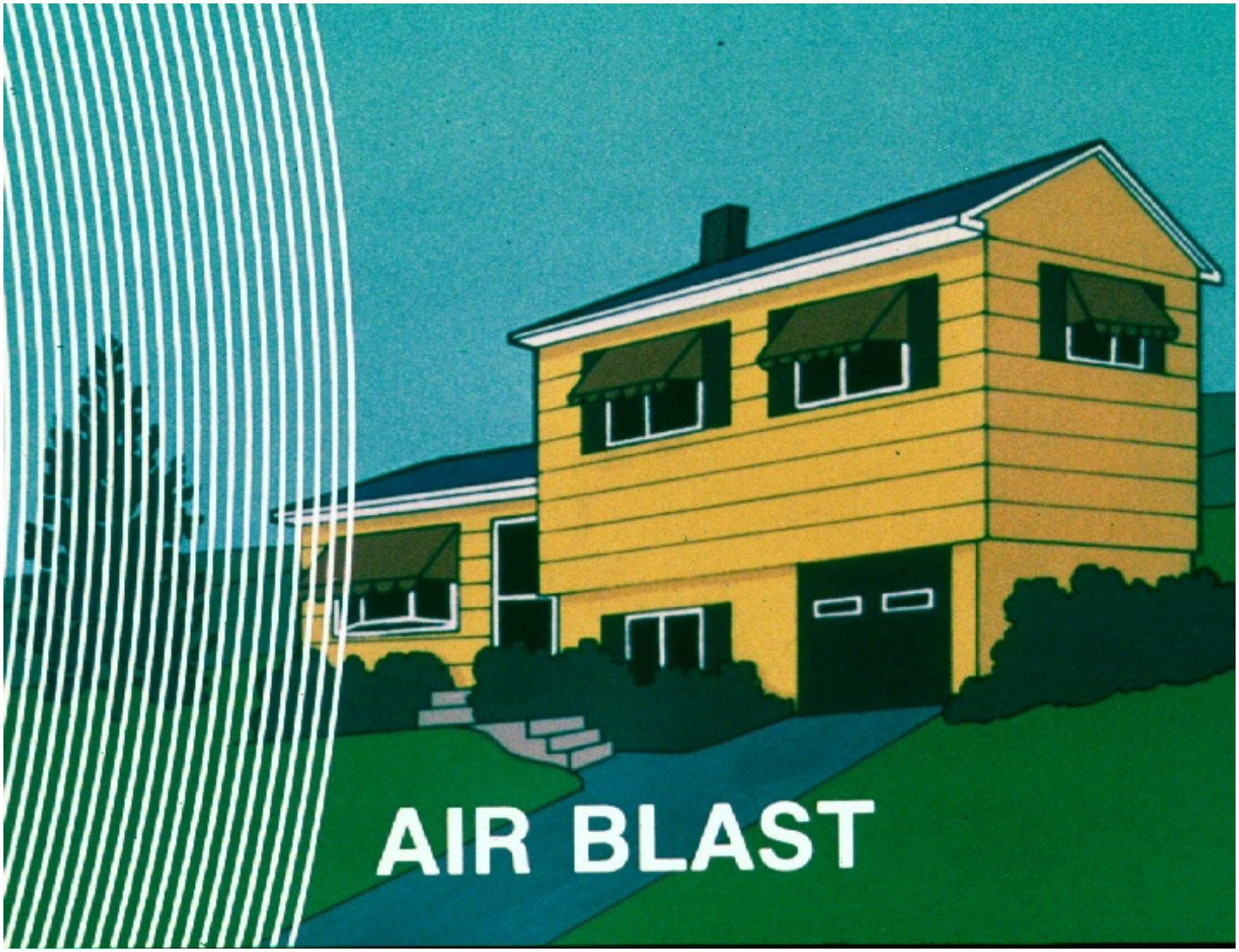

CAL



# Ground Vibrations

| **Distance** | **SD** | **PPV** |
|---|---|---|
| < 301 | 50 | 1.25 |
| 301 – 5000 | 55 | 1.00 |
| > 5000 | 65 | 0.75 |

# Airblast – Pressure Wave



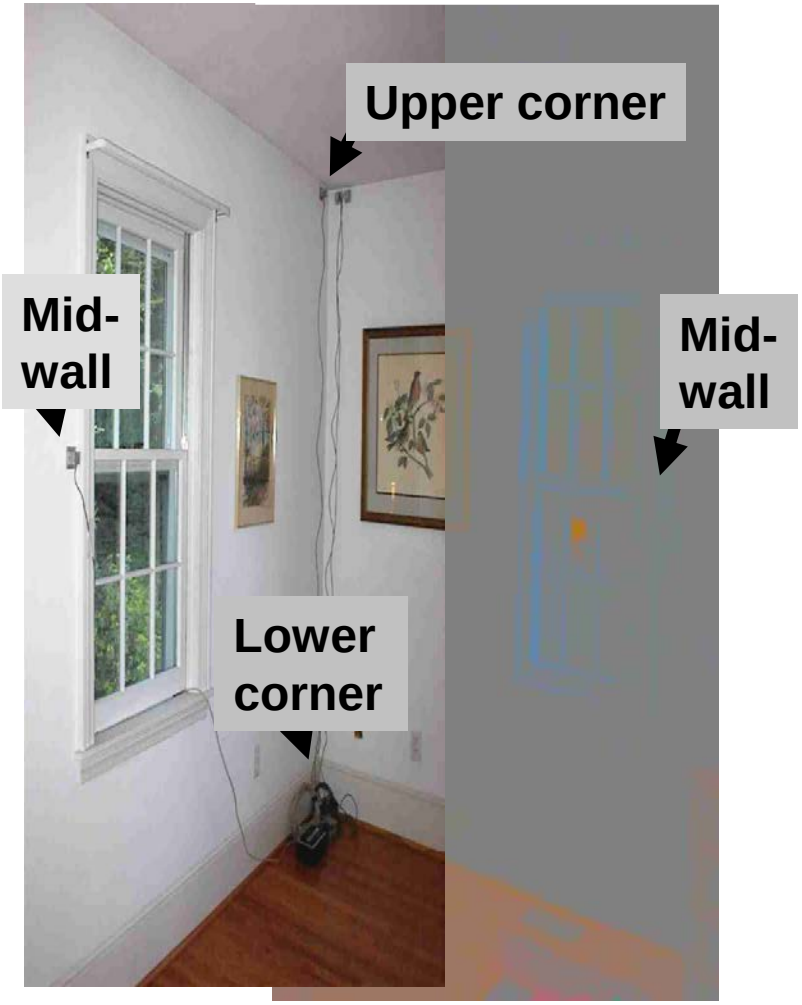
# Airblast

2 Hz microphone 133 dB

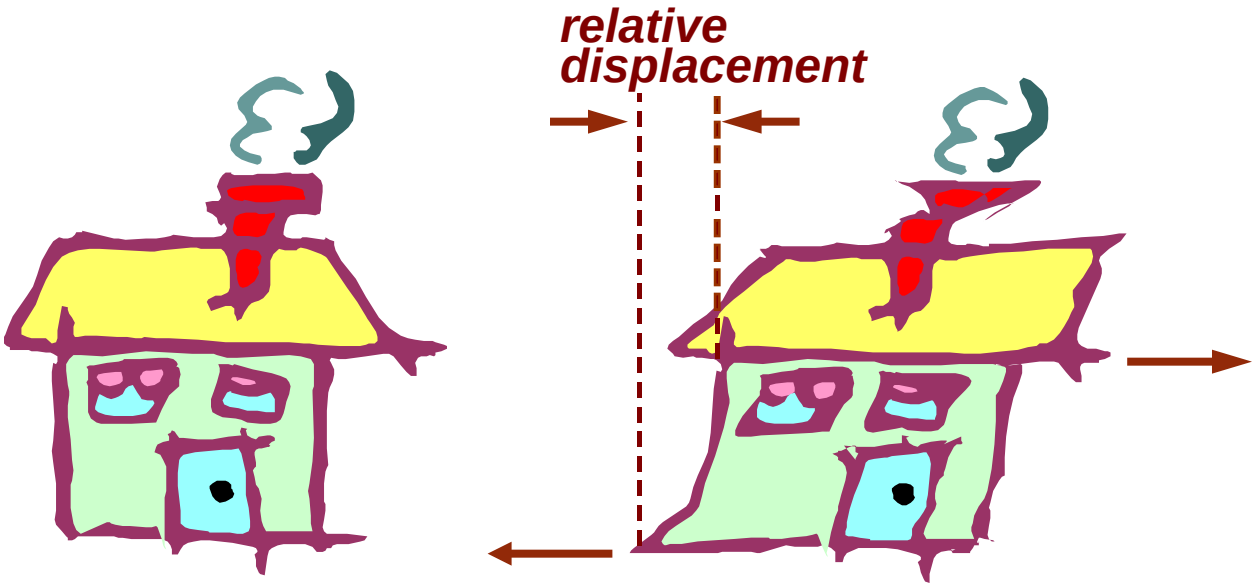
All seismographs manufactured today have 2 Hz lower frequency response range.

# Structure Response

- Structure distortions are caused both by ground and air vibrations
- Fall into two categories
  - whole structure
  - mid-wall

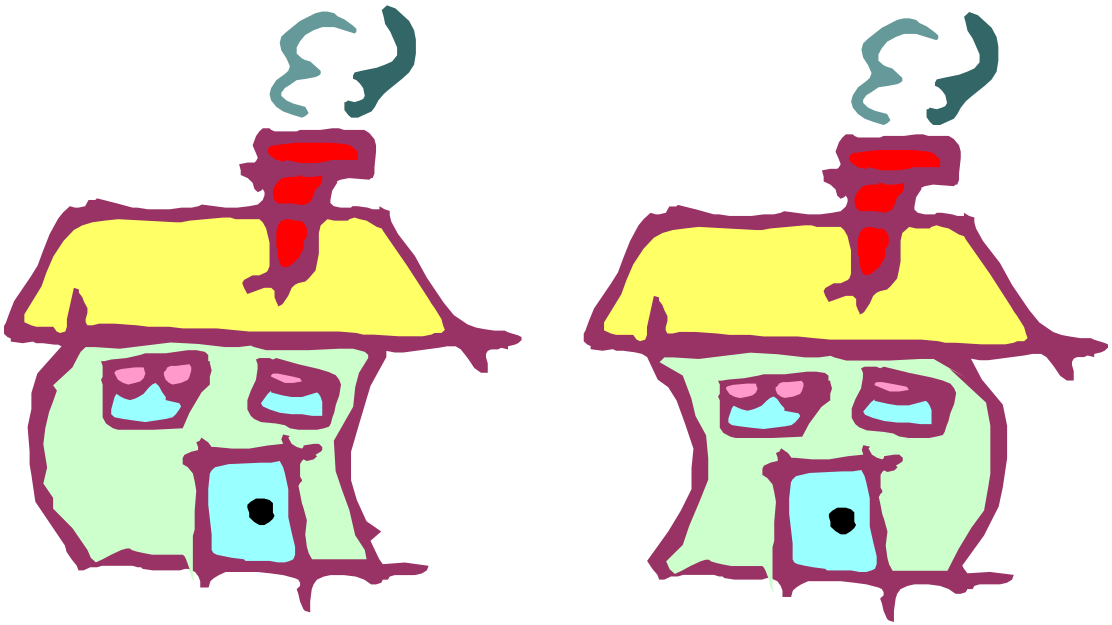


# Whole structure response




Whole structure shear distortions cause wall strains that may lead to wall cracking

# Mid-wall response



Move like a drum and result in rattling (noise) of loose objects on, or resting against walls.

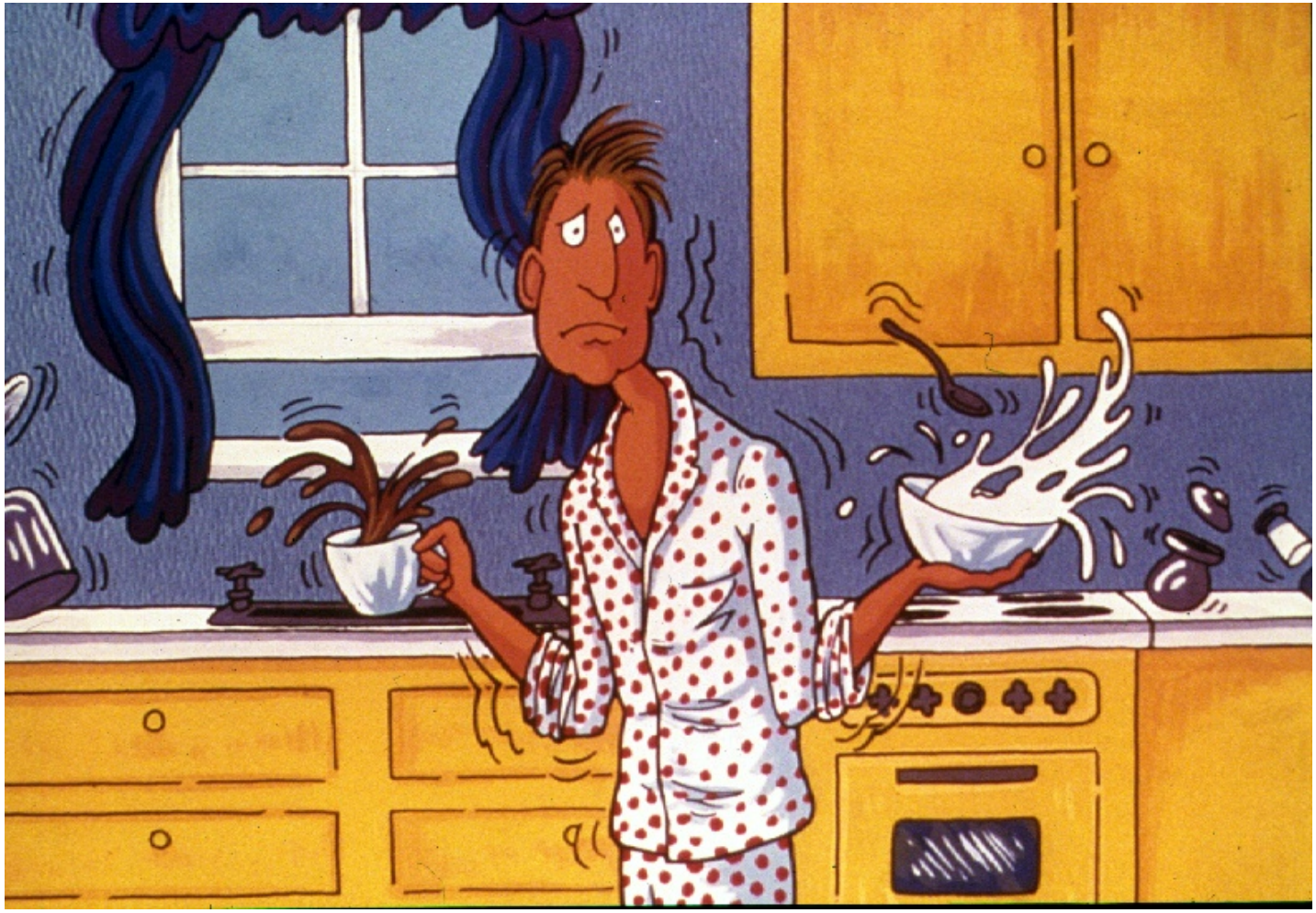
Motions do not result in wall cracking. But the noise can startle occupants, promoting the perception of structure damage.

# What is the worst case scenario of response?

**When the frequency of the ground or air pulse is close to the natural or fundamental frequency of the structure**

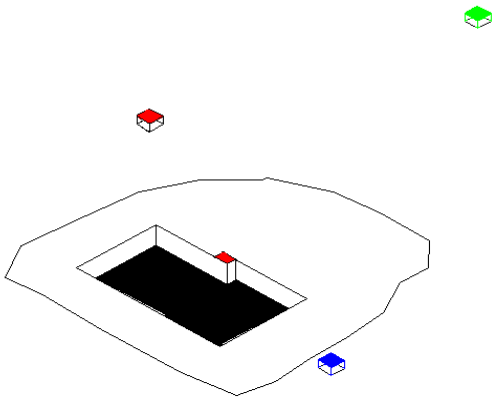
- **the structure will temporarily resonate at the fundamental mode**
- **the time duration of structure shaking may be far longer than that of the ground**
- **structures may exhibit an amplification of the ground excitations**

# When the house shakes, owners are Annoyed or Fear Damage



# What are the Most Important Parameters in Evaluating the Adverse Effects?

- Location of the blast
- Location of the compliance house
- Distance between the two
- Charge weight per delay
- Confinement
- Type of blast



# Coal Mine Blasting Records

## AUSTIN POWDER COMPANY BLAST REPORT

DATE: ____ / ____ / ____ (MO DA YR)

SHOT NO. _____ TIME OF BLAST _____ ☐ AM ☐ PM

COMPANY (PERMITTEE) _____ LOCATION _____

PERMIT NO. _____ LOCATION AT PLANT/PIT _____

*WEATHER:* ☐ CLOUDY ☐ CLEAR *TYPE OF TERRAIN:* ☐ HILLY ☐ FLAT *WIND DIRECTION:* (Circle One) (N) (NE) (E) (SE) (S) (SW) (W) (NW)

VELOCITY _____ /MPH TEMPERATURE _____ /DEGREES F

NEAREST PROTECTED STRUCTURE:

NAME OF STRUCTURE AND/OR TYPE _____ DISTANCE _____ /FT.

DIRECTION/BEARING _____ (IN OHIO, DIRECTION MUST BE STATED IN DEGREES)

OR COMPASS POINT *(Circle)* (N) (NE) (E) (SE) (S) (SW) (W) (NW)

METHOD USED: ☐ MEASURED ☐ GRID MAP ☐ TOPO MAP ☐ OTHER: _____

TYPE OF MATERIAL BLASTED _____ HOLE DIAMETER _____ AVE. DEPTH OF WATER _____

NO. OF HOLES _____ NO. OF ROWS _____ BURDEN _____

SPACING _____ DEPTH _____ FACE HEIGHT _____ BACK FILL DEPTH _____

SUB-DRILLING _____ LENGTH OF STEMMING _____ TYPE OF STEMMING _____

WERE BLASTING MATS USED: ☐ YES ☐ NO IF YES, TYPE USED: _____

EXPLOSIVES TOTAL QUANTITY

_____ MANUFACTURER _____

_____ MANUFACTURER _____

_____ MANUFACTURER _____

_____ MANUFACTURER _____

_____ MANUFACTURER _____

_____ MANUFACTURER _____

TYPE OF PRIMER _____ MANUFACTURER _____

TOTAL WEIGHT OF EXPLOSIVES (INCLUDE PRIMERS) _____

TYPE OF INITIATION SYSTEM: ☐ ELECTRIC MANUFACTURER _____

☐ NON ELECTRIC MANUFACTURER _____

DELAY DETONATORS USED (TYPE) _____

INITIATION METHOD: ☐ SEQUENTIAL MACHINE/TIMER SETTING _____ OHMS resistance each series or circuit, and total circuit resistance

☐ CD-450 _____

☐ CD-600 _____

☐ OTHER (NAME) _____

CIRCLE SCALE DISTANCE USED: W = (D/50)² W = (D/85)² _____

W = (D/55)² W = (D/ )² _____

LEGAL WEIGHT OF EXPLOSIVES PER DELAY _____

***CHECK YOUR STATE & LOCAL REGULATIONS FOR PROPER SCALE DISTANCE.***

WEIGHT OF EXPLOSIVES PER HOLE _____ (SIGNIFICANT VARIATIONS SHOULD BE EXPLAINED

MAX. NO. OF HOLES WITHIN 8MS PERIOD _____ ON BACK AND IDENTIFIED IN SKETCH.)

MAX. WT. OF EXPLOSIVES WITHIN 8MS PERIOD _____ ACTUAL S/D _____

TOTAL NO. OF TONS PRODUCED _____ OR TOTAL CUBIC YARDS PRODUCED _____

TOTAL POWDER FACTOR: ☐ LBS/CUBIC YARD _____

☐ TONS/LB _____ TONS/CUBIC YARD _____

☐ CHECK HERE, IF BLAST OCCURRED AT A TIME OTHER THAN THE SCHEDULED TIME EXPLAIN WHY IN THE COMMENT SECTION.

☐ CHECK HERE, IF A MISFIRE OCCURRED. IF MISFIRE OCCURRED, EXPLAIN PROCEDURE USED TO ELIMINATE THE HAZARD. PLEASE USE COMMENT SECTION.

SEISMOGRAPH DATA: DATE OF SEISMOGRAPH _____ TIME OF SEISMOGRAPH READING _____ ☐ AM ☐ PM

TYPE OF INSTRUMENT _____ SENSITIVITY _____

CALIBRATION SIGNAL OR DATE OF CALIBRATION _____

LOCATION: DISTANCE FROM BLAST & LOCATION _____

DIRECTION FROM BLAST (N) (NE) (E) (SE) (S) (SW) (W) (NW)

SEISMIC DATA: T _____ V _____ L _____ DB _____

DIGITAL READOUT: ☐ YES ☐ NO

NAME OF PERSON TAKING SEISMIC READING _____ FIRM _____

NAME OF PERSON OR FIRM ANALYZING RECORD _____

FORM 224-8 REV. 1-68

**ATTACH SEISMIC RECORD IF AVAILABLE**

# Blaster and Crew

**Blaster Certification**

30 CFR 850 - States have counterparts

- Experience
- Training
- Testing

Responsible Party or Employee Possessor?

**Blasting Crew**

30 CFR 816.61 General requirements.

(ii) Give direction and on-the-job training to persons who are not certified and who are assigned to the blasting crew or assist in the use of explosives.

# Why Blasting Records?

- Regulatory requirement
- Post blast assessment - analyzing problems
- Liability protection - Documentation or Evidence of the actual blast … “Eye-Witness Testimony”

# COAL MINE BLAST REPORT

General

**Permit #** _____ **Date** _____

**Permittee** _____ **Operator** _____ **Time (Hrs)** _____

Blaster _____ Signature _____ Cert. _____ Exact Location (GPS) _____

Weather / Sky Coverage _____ Temp F _____ Wind speed / direction _____ Coal seam _____

**Protected Structures** Name _____ Distance (ft) _____ Azimuth _____ Scale Distance _____

Utility /other feature Name _____ Distance (ft) _____ Azimuth _____ Scale Distance _____

**Material blasted** (%) Sandstone _____ Shale _____ Limestone _____ Other _____

**Blast Type** Breakdown _____ Presplit _____ Cast _____ Production _____ Other _____

Diameter _____ Burden _____ Spacing _____ Cubic yards blasted _____ Average PF _____ Highest PF _____

Hole depth (ft) _____ # holes _____ Stemming (ft) _____ Type _____ Interdeck (ft) _____ Backfill (ft) _____ Total feet _____

Hole depth (ft) _____ # holes _____ Stemming (ft) _____ Type _____ Interdeck (ft) _____ Backfill (ft) _____ Total feet _____

**Explosives** ANFO _____ Emulsion _____ Blend _____ Boosters _____

**Type and Weight** Density _____ Density _____ Density _____ # used _____

Manufacturer _____ Manufacturer _____ Manufacturer _____ Manufacturer _____

Maximum exp. / hole (lbs) _____

Maximum charge weight / 8 ms delay _____ Max. # charges / 8ms _____ Total weight of explosives in blast _____

Design

**Detonators** Delay Quanity Delay Quanity

Electric _____ Nonelectric _____ Lead Line (ft) _____ Blasting Machine/Initiation Method _____

Series _____ Det cord (ft) _____

yes / no _____

Parallel _____ Other _____

No.circuts _____

**Blasting Seismograph Data**

Seismograph Model _____ Location _____ Distance (ft) _____ PPV (in/s) L T V

Operator _____ Trigger levels (PPV/dB) _____ Air (dB) _____ Frequency L T V

Analyst _____ Calibration Date _____

Blasting crew _____

Comments: Mats or other protection used or reasons and conditions for an unscheduled blast

Seismograph

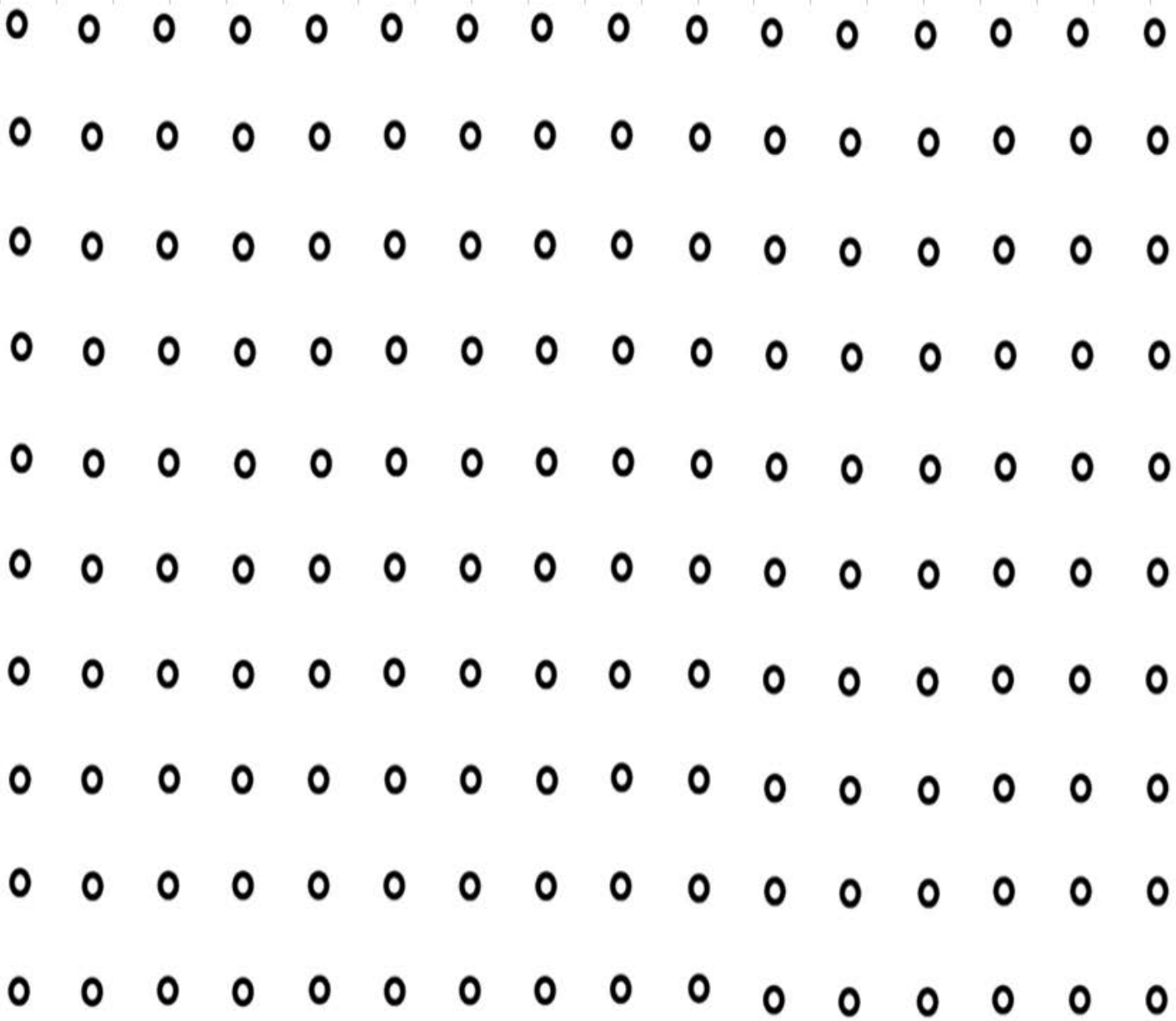
Page 1

Date _____ Time _____ Permit # _____

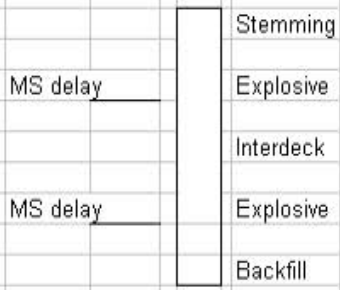
Sketch the blast pattern and illustrate the surface and down hole delays

**Include the amount of explosives in each hole**

# Cross Sections



**Profile A**




**Profile B**

**Profile C**

# 30 CFR Sec. 816.68
# Use of Explosives: Records of Blasting Operations.

• The operator shall retain a record of all blasts for at least **3 years**.

•Upon request, copies of these records shall be made available to the regulatory authority and to the public for inspection.

• Such records shall contain the following data:

(a) Name of the operator conducting the blast.
(b) **Location**, date, and time of the blast.
(c) Name, signature, and certification number of the blaster conducting the blast.

# Exact Location

- Locate the blasting pattern within the permit boundary
- Global Positioning System
  - Lat-Long, Decimal seconds
  - UTM
- Distance and Azimuth or Bearing
- Grid maps
- Project station
- Garmin GPS and TopoFusion

(d) **Identification, direction and distance**, in feet, from the nearest blast hole to the nearest dwelling, public building, school, church, community or institutional building outside the permit area, except those described in Section816.67(e).

(e) Weather conditions, including those which may cause possible adverse blasting effects.

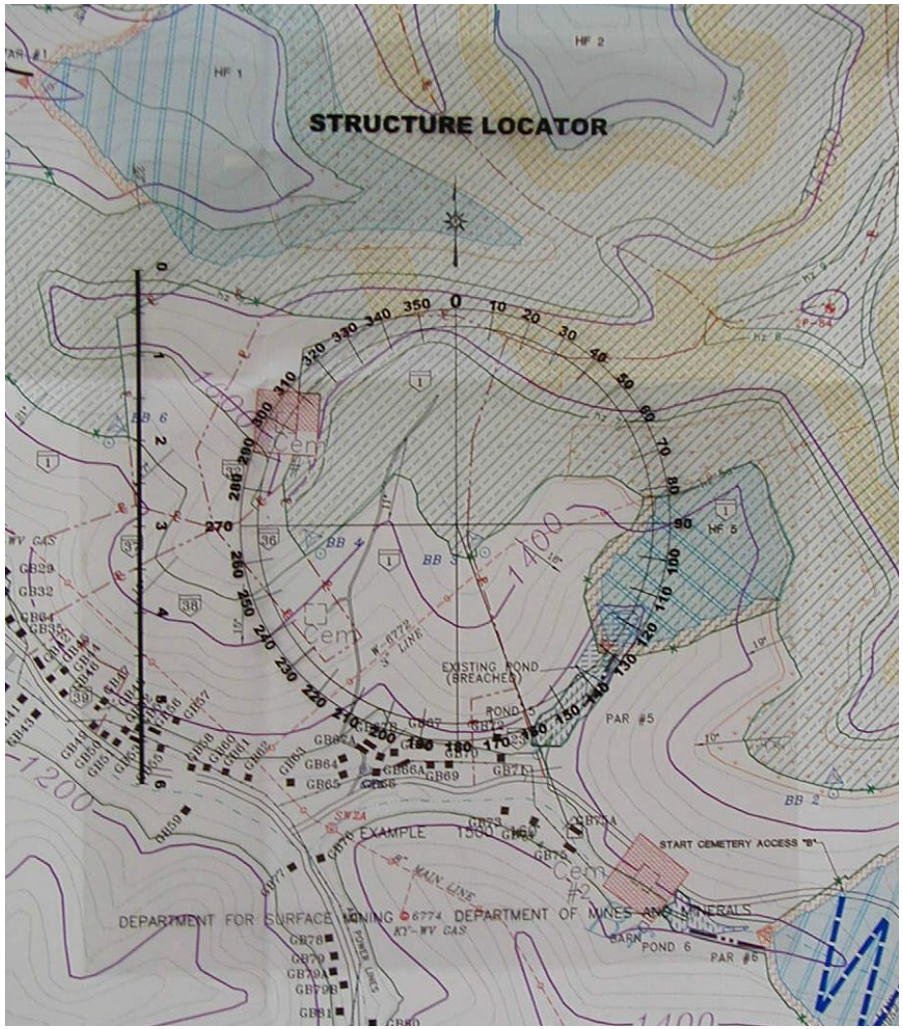
(f) Type of material blasted.

# Identify Protected Structure

Use the correct structure

- Street Address
- Full name of occupant
- House number from permit or project maps

# Distance and Direction




- Distance from the closest blast hole
- Cardinal directions are too general
- Azimuth to the structure from the blast site is preferred

Eg. 1500 feet 160 degrees

# Blast Details

(g) **Sketches of the blast pattern including number of holes, burden, spacing, decks, and delay pattern.**

(h) Diameter and depth of holes.

(i) Types of explosives used.

(j) **Total weight of explosives used per hole.**

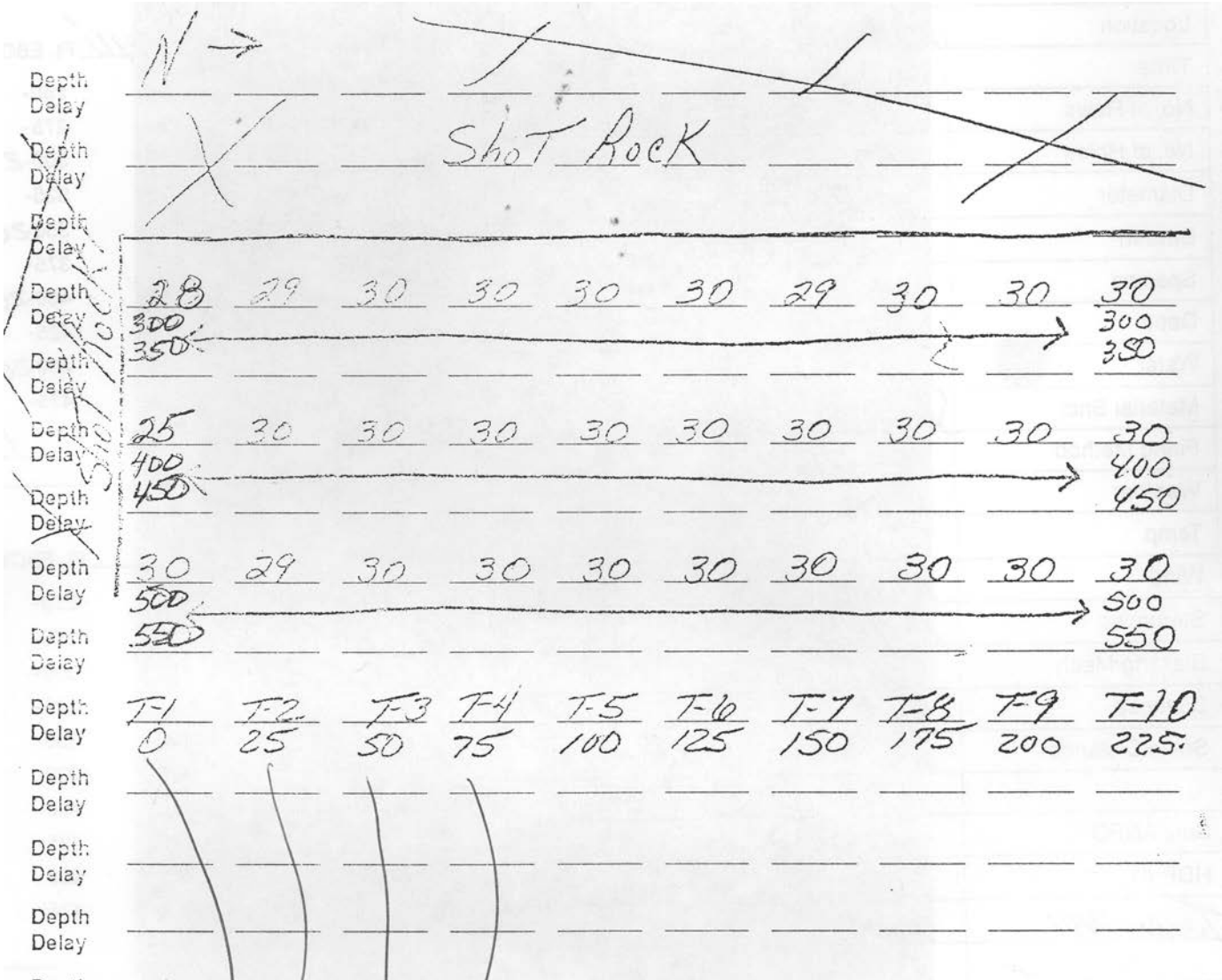
(k) The maximum weight of explosives detonated in an 8-millisecond period.

(l) **Initiation system.**

(m) Type and length of stemming.

(n) Mats or other protections used.

# Sketches of Blast Pattern

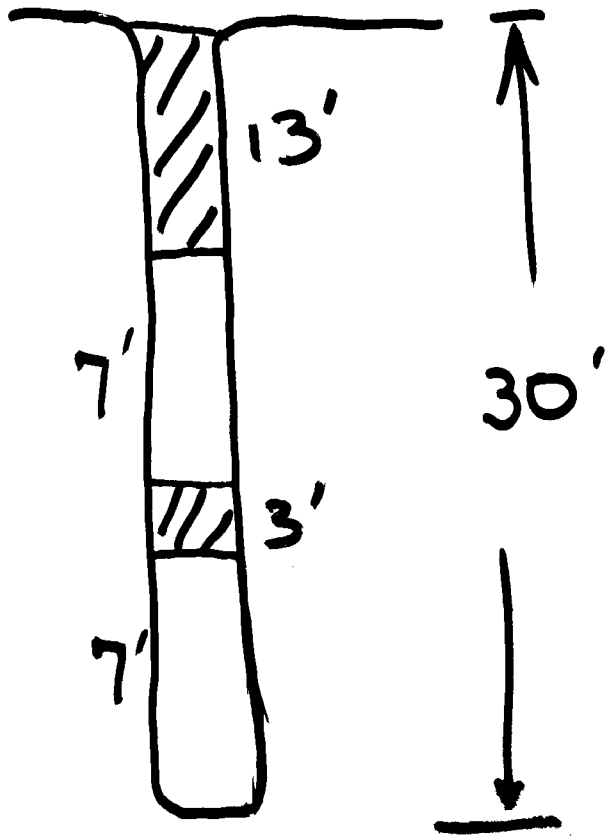


$$LD = 0.34(d)^2 \times \rho$$

$$= 0.34(6.75)^2 \times 0.92$$

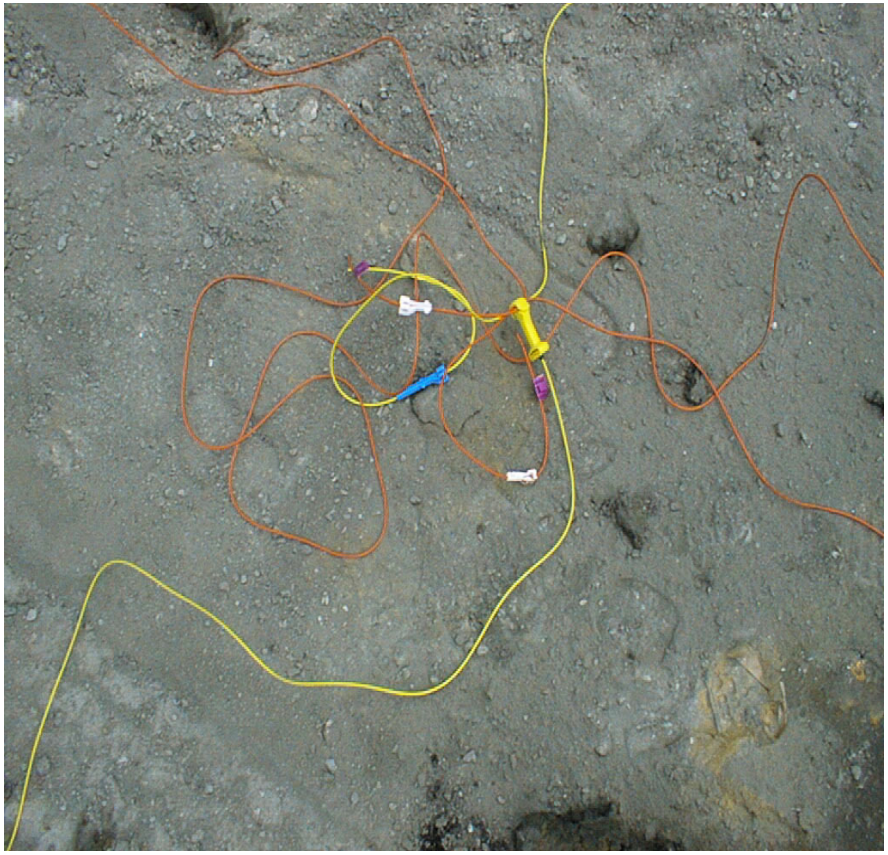
$$= \underline{14.6 \text{ lb/ft}}$$

$$CW = 14' \times 14.6 = \underline{\underline{205 \text{ lb}}}$$




# Explosives used per Hole

# Initiation System



Electric

- Cap numbers
- Sequential Blasting Machine settings

Nonelectric

- Surface MS times
- Downhole MS times

(o) Seismographic and airblast records, if required, which shall include--

(1) Type of instrument, sensitivity, and calibration signal or certification of annual calibration;

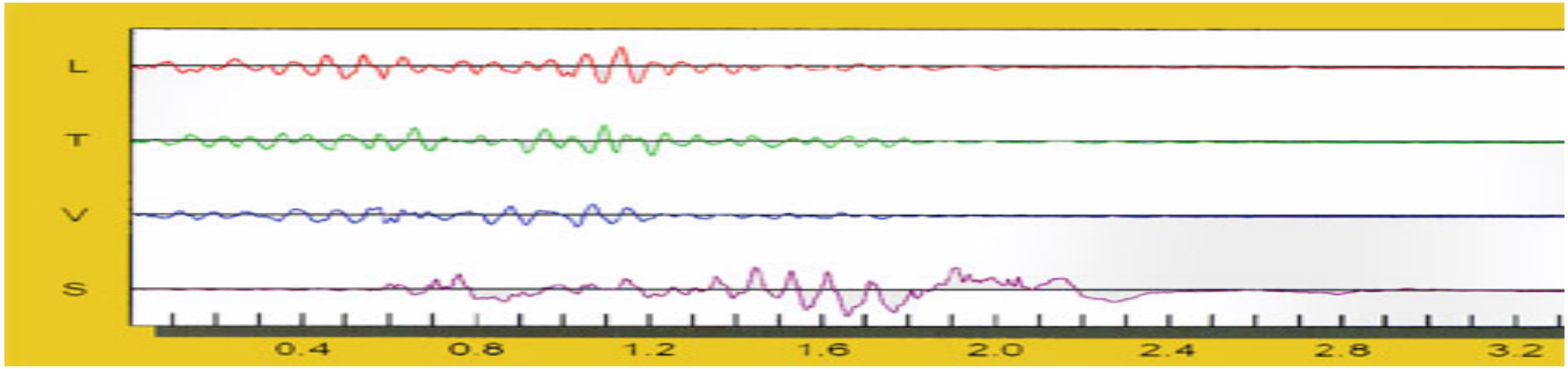
(2) Exact location of instrument and the date, time, and distance from the blast;

(3) Name of the person and firm taking the reading;

(4) Name of the person and firm analyzing the seismographic record; and

(5) The vibration and/or airblast level recorded.

# Blasting Seismographs




- Seismograph location
  - Address or map ID #
- Name of seismo operator
  - Full name
- Highest PPV and dB
  - Record the highest trace PPV
  - Record dB level
  - Attach wave form printout

# (p) Reasons and conditions for each unscheduled blast.

List any remarkable event

- Flyrock
- Cutoffs or Misfires
- Cracked rock strata
- Holes left unloaded
- Site security issues

# OSM Requires Blast Records

Each mine must maintain for a period of at least **three years** and make available for public inspection upon request **a log** detailing the location of the blasts, the pattern and depth of the drill holes, the amount of **explosives used per hole**, and **the order and length of delay in the blasts**;

ATF is a member of the public!!

# Useful Blast Log Items to ATF

- Number of holes
- Initiation System
- Amount of explosives per hole
  - Main charge (ANFO, Emulsion)
  - Boosters (High Explosives)
  - Detonators (Down Hole Detonators)
- Delay sequence (Surface Detonators)

# OSM Resources

- National Technical Training Program (NTTP)
  - Blasting and Inspection
  - Advanced Blasting: Investigation and Analysis of Adverse Effects
- Technical Innovation and Professional Services (TIPS) **www.tips.osmre.gov**
  - Blast Log Evaluation Program (BLEP)
- Appalachian Region Blasting Web Page
  - **www.ARblast.osmre.gov**

# OSM Contacts

- Appalachian Region – Pittsburgh, PA
  - Ken Eltschlager, Mining/Explosives Engineer
  - keltschlager@osmre.gov or (412) 937-2169
- Mid-Continent Region - St. Louis, MO
  - David Best, Civil Engineer
  - dbest@osmre.gov or (618) 463-6463 x123
- Western Region – Denver, CO
  - Mike Rosenthal, Mining Engineer
  - mrosenthal@osmre.gov or (303) 844-1400 x1453