SITE CHARACTERIZATION

Part 1. Non-Intrusive Site Characterization Technologies

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Site Characterization
Non-intrusive Technologies

- Factors to Consider When Designing a Site Characterization Program
- Review of Pre-Existing Information
- Site Reconnaissance
- Development of a Dynamic Site Conceptual Model
- Soil Gas Surveys
- Surface Geophysical Methods

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SITE CHARACTERIZATION CONSIDERATIONS

- Objectives of the site assessment
- Physical geography of the site
- Anthropogenic Influences
- Geology and Hydrogeology
- Types and Characteristic of Contaminants

WHAT ARE THE OBJECTIVES OF THE CHARACTERIZATION

- Property Transfer
  - Limited
- Delineation of Contamination
  - Intensive
- Litigation
  - Very Intensive
- Remediation Program
  - Progressively More Intensive

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TODAY'S FOCUS
CONTAMINATED SITE INVESITGATION

- Characterization of the geography, geology, hydrogeology, and conditions that control contaminant fate and transport
- Identify and characterize the source area
- Define the lateral and vertical extent of soil contamination
- Determine the horizontal and vertical extent of groundwater contamination

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FACTORS TO CONSIDER WHEN CONSIDERING TECHNOLOGIES FOR SITE INVESTIGATION

- Nature of subsurface materials
- Complexity of the geology and hydrogeology
- Depth to groundwater
- Nature and characteristics of contaminants
- Nature of the contaminant source

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CHARACTERISTICS OF A WELL PLANNED AND COST-EFFECTIVE SITE INVESTIGATION

- Clear understanding of the objectives
- Identify the data necessary to achieve the objectives
- Develop a “preliminary” dynamic Site Conceptual Model
- Begin by making optimum use of existing data
- Then move from non-intrusive, rapid data acquisition toward more intrusive investigation technologies

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NON-INTRUSIVE SITE CHARACTERIZATION TECHNOLOGIES

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REVIEW EXISTING INFORMATION

- Published and unpublished literature on regional geology and hydrogeology
- Topographic maps and aerial photographs
- Site historical information and newspaper archives
  - Manufacturing processes
  - Hazardous material handling, storage, and disposal practices
- Existing site investigations
  - Review boring logs or well logs
  - Review aquifer characterization or any earlier attempts of source and contaminant delineation

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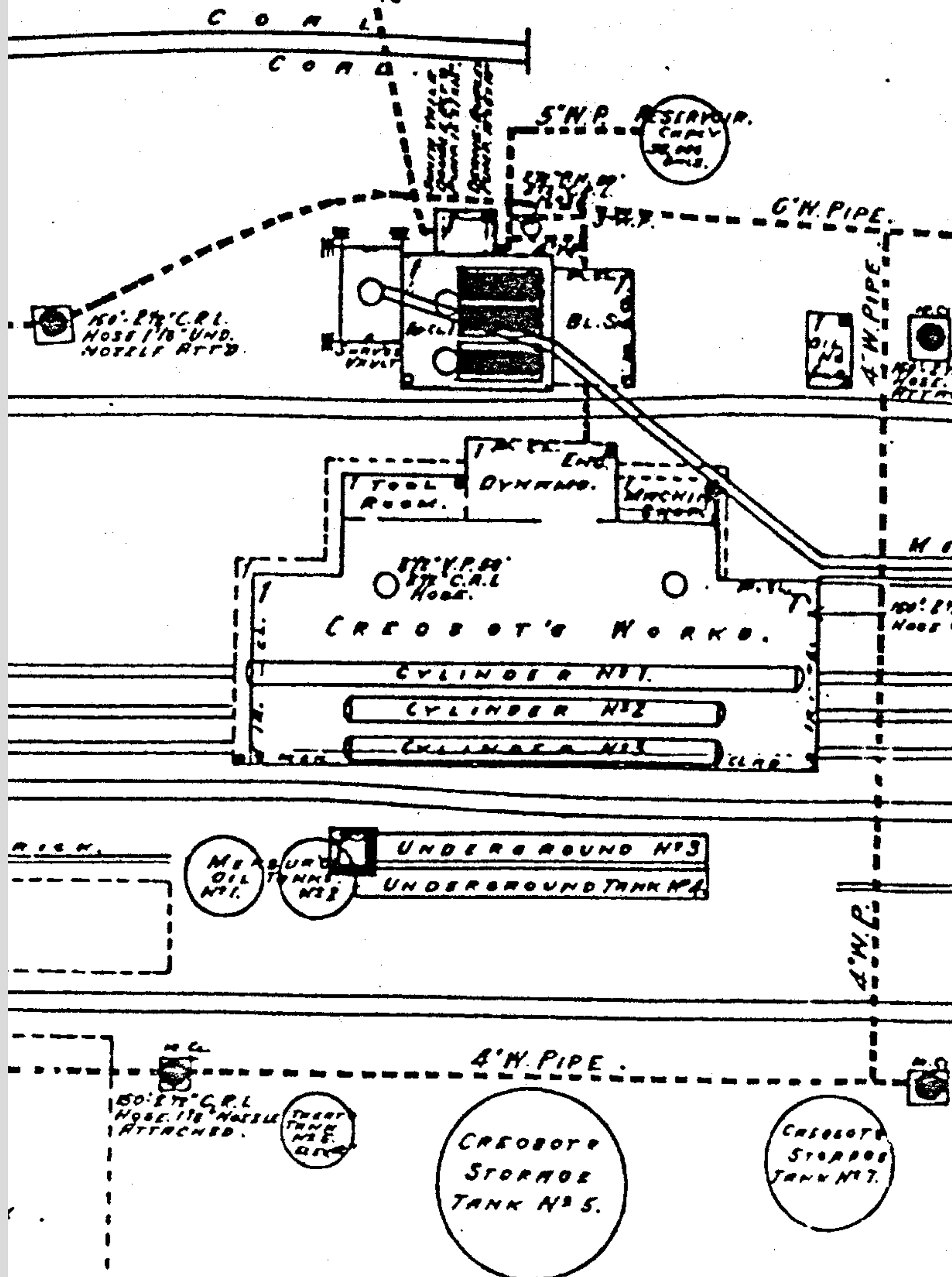
Sanborn Fire Insurance Maps



AERIAL PHOTOGRAPHS FOR SITE INVESTIGATION

An inexpensive, noninvasive tool to assess . . .

- Historic site use and conditions
  - Source areas
  - Land use
  - Drainage
  - Vegetative stress
  - Surface contamination
  - Geology
  - Relate environmental data to historic site conditions
- Fracture trace analysis
  - Preferential pathway analysis
  - Well siting

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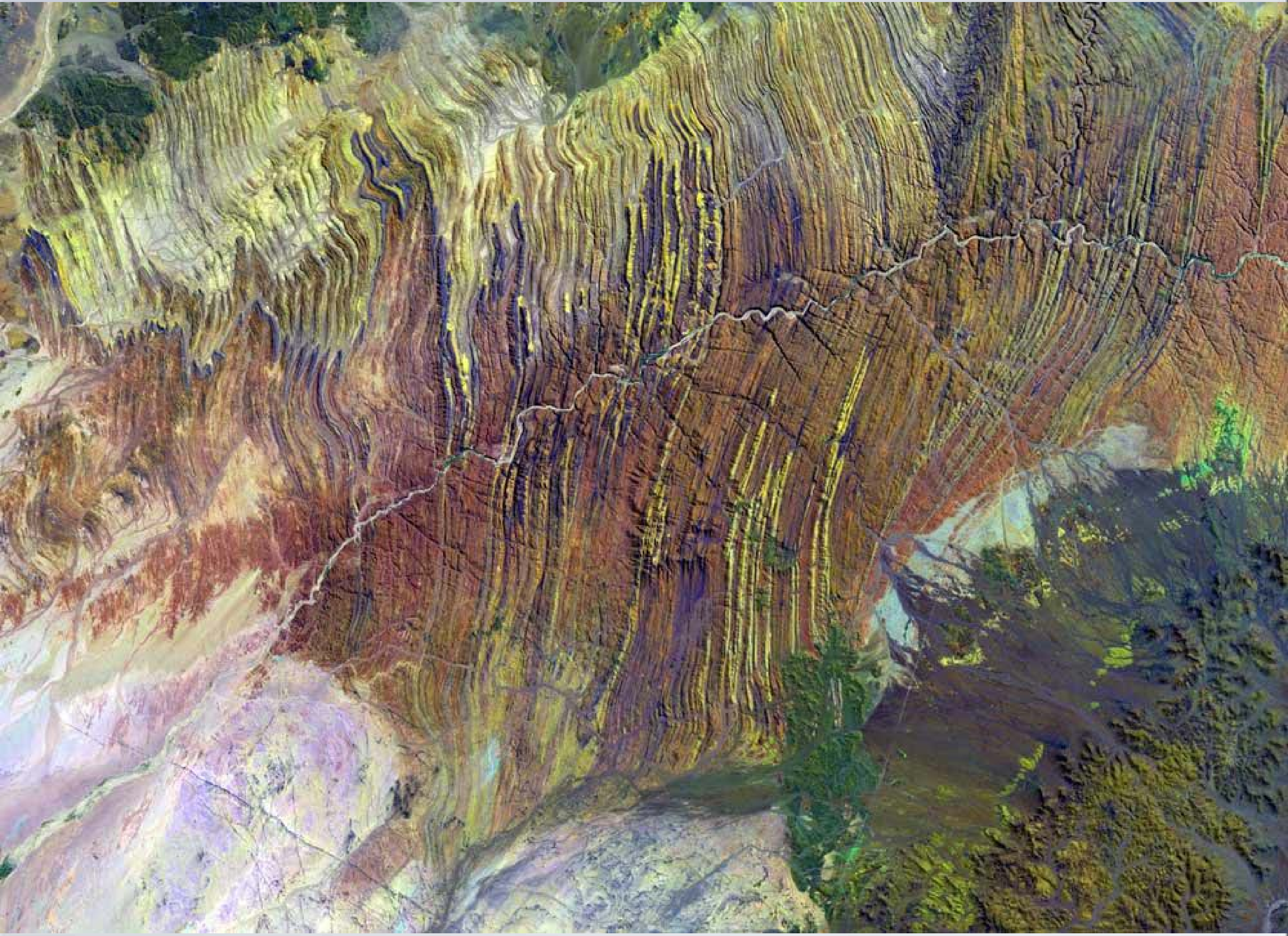
TYPES OF AERIAL PHOTOGRAPHS

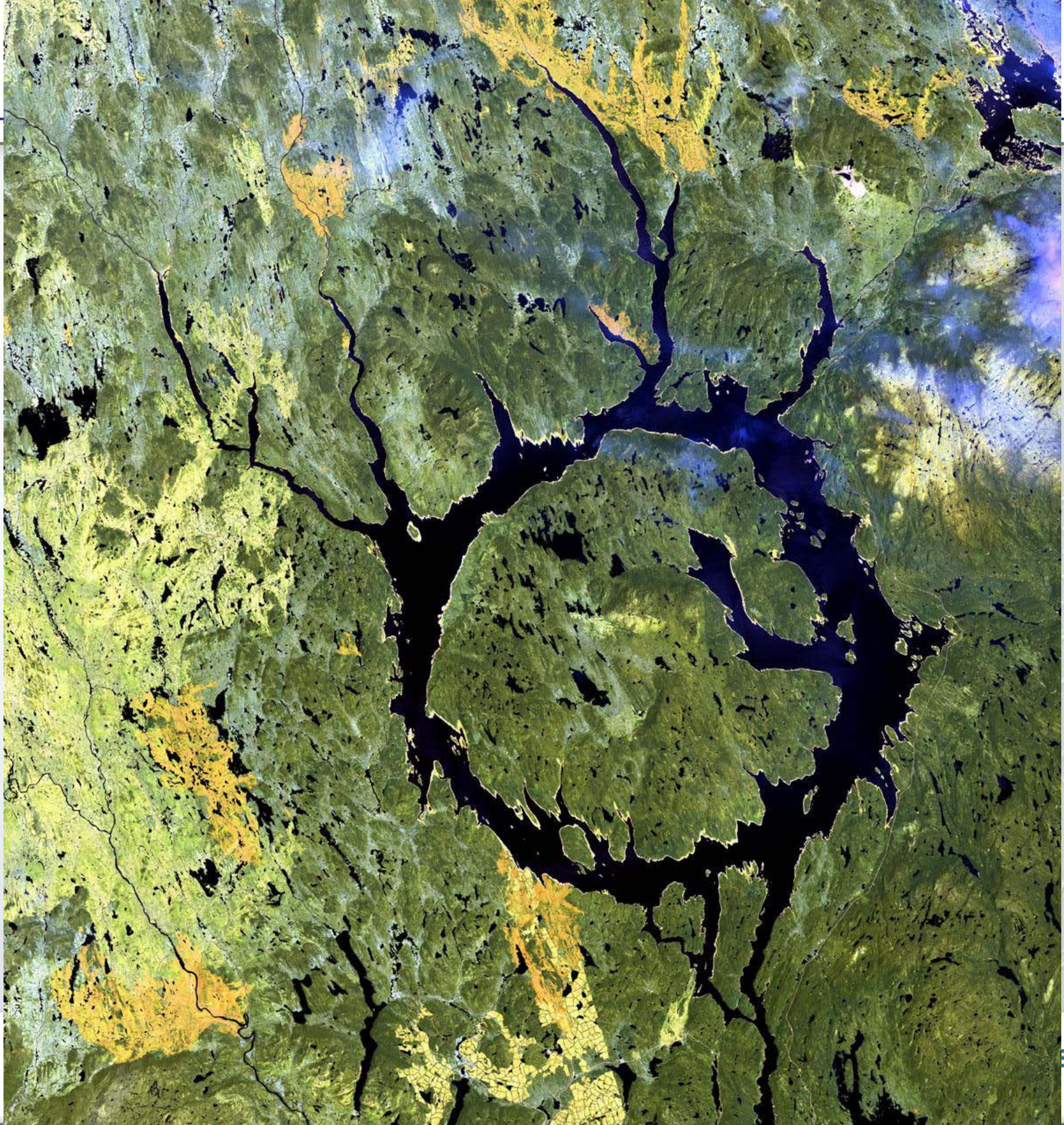
- Historic black & white photography
- Color aerial photography
- Infrared imagery
- Airborne radar imaging
- Multi-spectral imagery


Love Canal – 1938


Love Canal – 1951

1966 oblique photo showing the rear end of a metal works facility where groundwater is contaminated by chlorinated solvents





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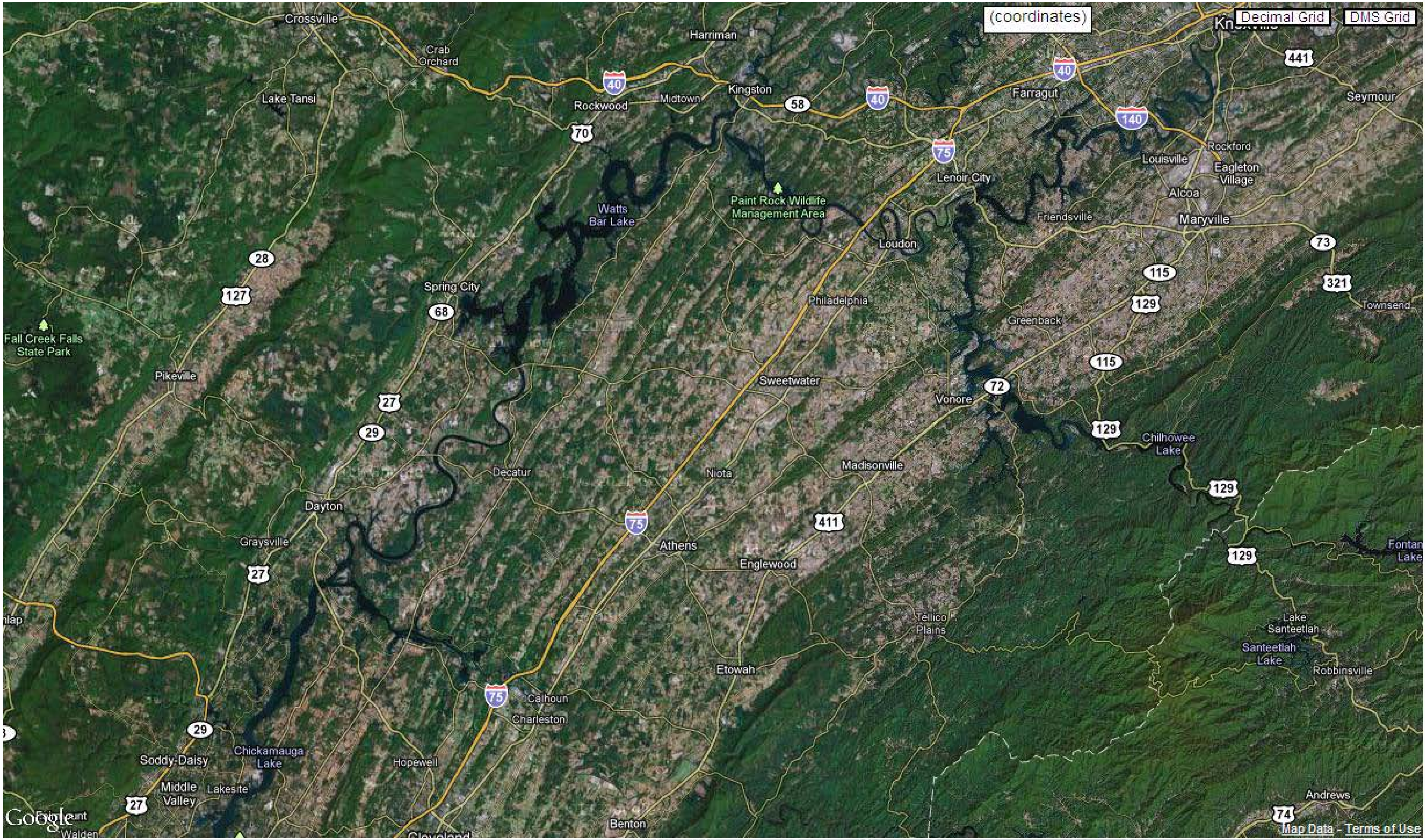
(coordinates)
Decimal Grid
DMS Grid
Crossville
Crab Orchard
Harriman
Rockwood
Midtown
Kingston
Farragut
Seymour
Lake Tansi
Rockford
Louisville
Eagleton Village
Alcoa
Lenoir City
Paint Rock Wildlife Management Area
Watts Bar Lake
Friendsville
Maryville
Loudon
Spring City
Philadelphia
Greenback
Townsend
Fall Creek Falls State Park
Pikeville
Sweetwater
Vonore
Chilhowee Lake
Decatur
Niota
Madisonville
Dayton
Athens
Englewood
Graysville
Tellico Plains
Lake Santeetlah
Santeetlah Lake
Robbinsville
Etowah
Calhoun
Charleston
Soddy-Daisy
Chickamauga Lake
Hopewell
Middle Valley
Lakesite
Benton
Andrews
Map Data - Terms of Use

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Dec 30, 2008
Maurertown
Woodstock
© 2011 Google
Image U.S. Geological Survey
Image USDA Farm Service Agency
Google
Imagery Date: May 19, 2008
38°54'43.83" N
78°25'40.10" W
elev 666 ft
Eye alt 11.91 mi

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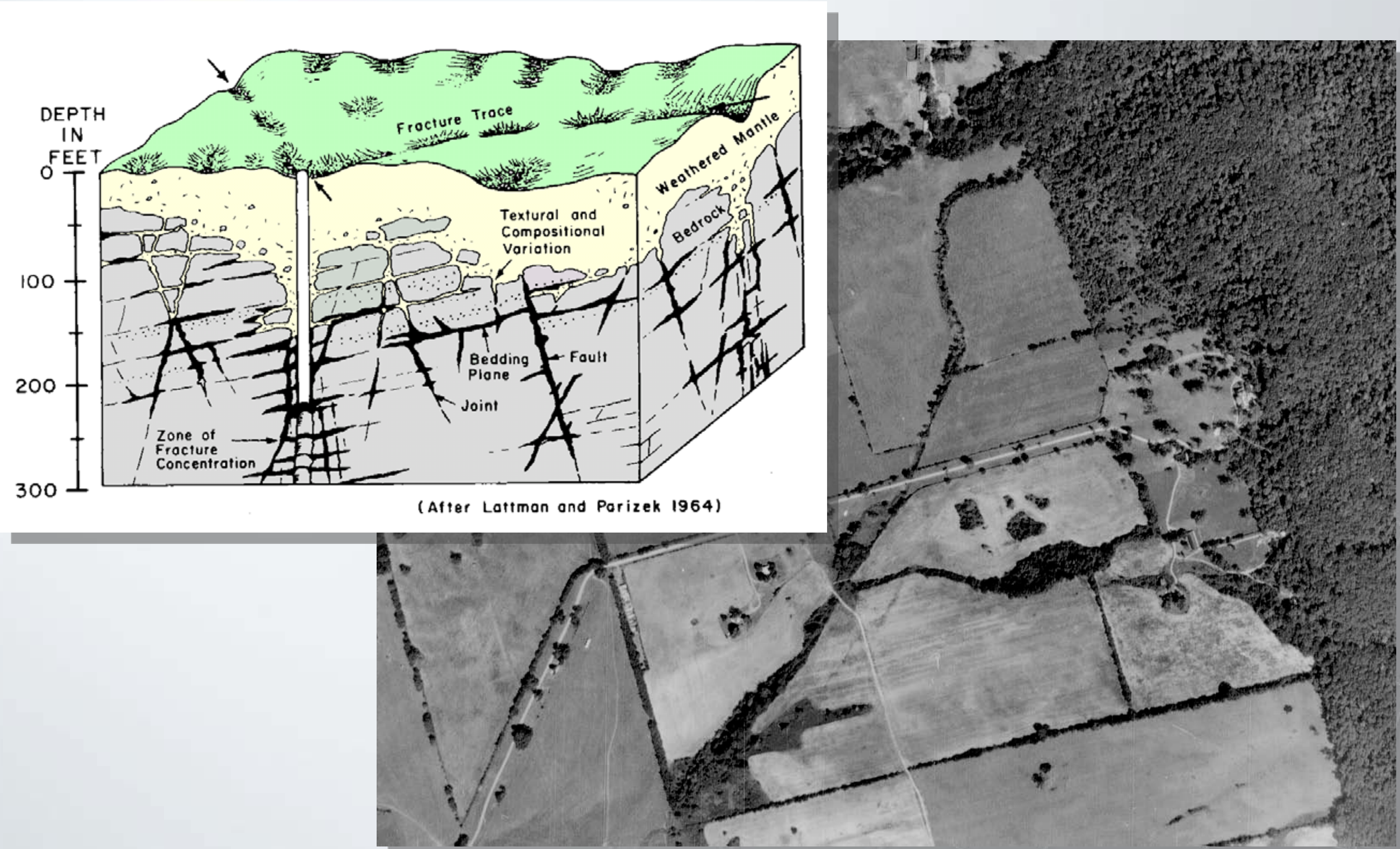
FRACTURE TRACE ANALYSIS



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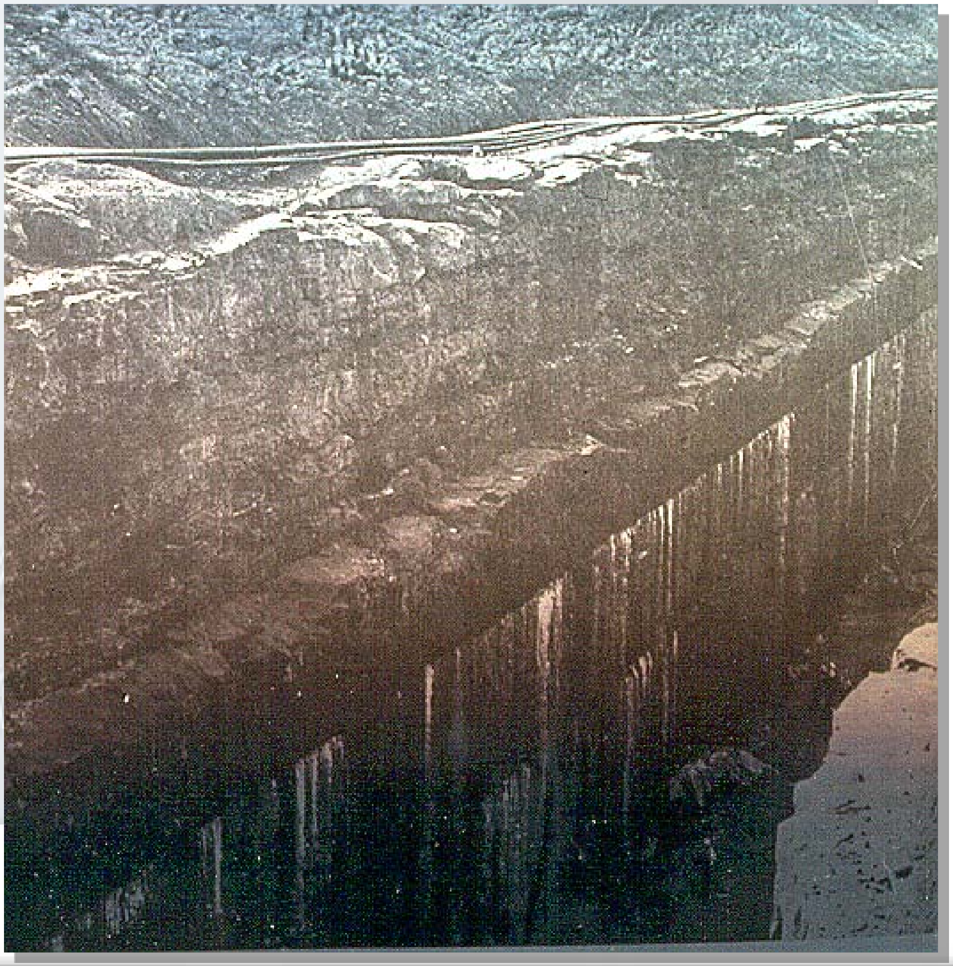
Vertical and Bedding Plane Fractures in the Lockport Dolomite Outcrop



CONDUCT A SITE RECONNAISSANCE

- Look at the characteristics of any geologic outcrops
- Examine topographic and geomorphic features
- Identify locations of surface and subsurface infrastructure
- Look for obvious signs of potential sources of contamination, and areas of environmental impairment

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DEVELOP A PRELIMINARY SITE CONCEPTUAL MODEL BASED UPON:

- Regional and site specific geologic and hydrogeologic conditions
- Site history and physical characteristics
- Nature and behavior of site-specific contaminants in the environment
- Identify and define data gaps to be filled to further refine the Site Conceptual Model

SELECTION OF APPROPRIATE METHODS OF NON-INTRUSIVE SITE CHARACTERIZATION

- Consider site's hydrogeologic characteristics
- Site history, records, and reports
- Nature of the suspected source area(s)
- Physical and chemical characteristics of any suspected contaminants
- Anthropogenic influences on contaminant migration
- Degree to which any site investigation may disrupt site operations

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SOIL GAS SURVEYS

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FACTORS AFFECTING THE APPLICABILITY OF SOIL GAS SURVEYS

- Volatility of the contaminant
- Understanding of the pathways of vapor migration
- Depth to the contaminant source
- Depth to groundwater
- Nature of subsurface materials
- Atmospheric conditions

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TYPES OF SOIL GAS SURVEYS

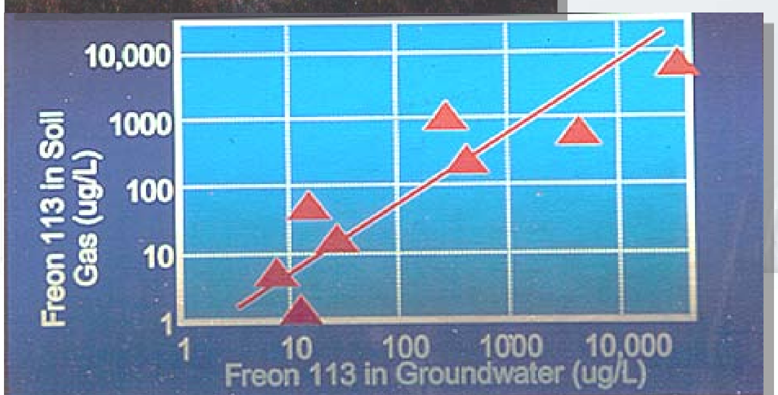
- Active sampling with real time analytical results
  - PID, FID, OVA, Mobile GC/MS
- Passive
  - Contaminant specific sorbent materials

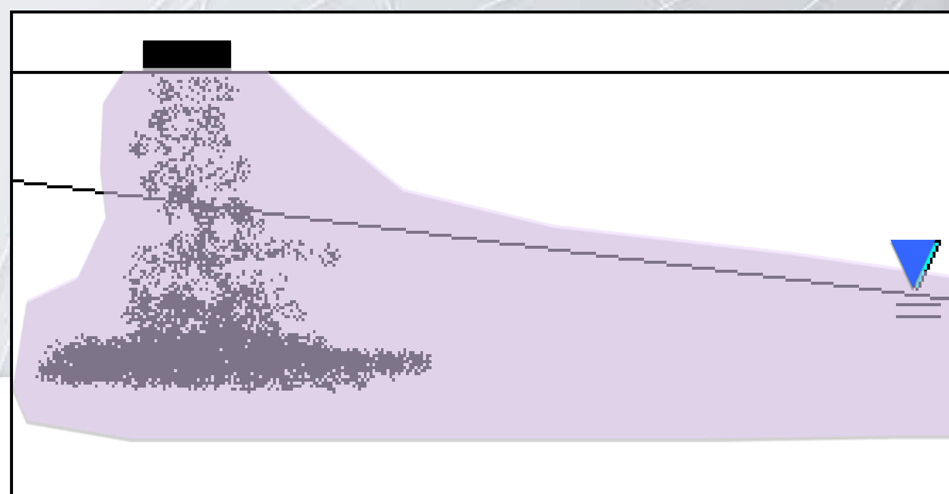
ADVANTAGES OF SOIL GAS SURVEYS

- Rapid delineation of source area(s) and contaminant distribution
- Can facilitate delineation of VOC groundwater plumes
- Provide real time data
- Cost-effective

Soil-Gas Surveys

- Rapid delineation of VOCs evolving from NAPL in the vadose zone (source areas)
- Delineate shallow soil or groundwater contamination
- Less effective for deep groundwater contamination





Soil-Gas Surveys (cont.)

- Older releases in hot environments (e.g., arid regions) may have limited signal due to high volatilization rates
- Passive soil gas as sampling technologies, e.g., Gore-Sorber® (cost: $125-225/sample + equipment cost $25-85/day + mob cost of $200-600/day)
- Active soil gas sampling technologies(cost: $110-190/sample)
- Phased approach: passive, active, vertical soil gas monitoring (LaPlante, 2002)

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DISADVANTAGES OF SOIL GAS SURVEYS

- Interpretation of data can be subjective
- Temperature and humidity can influence results
- May be difficult to identify deep VOC plumes

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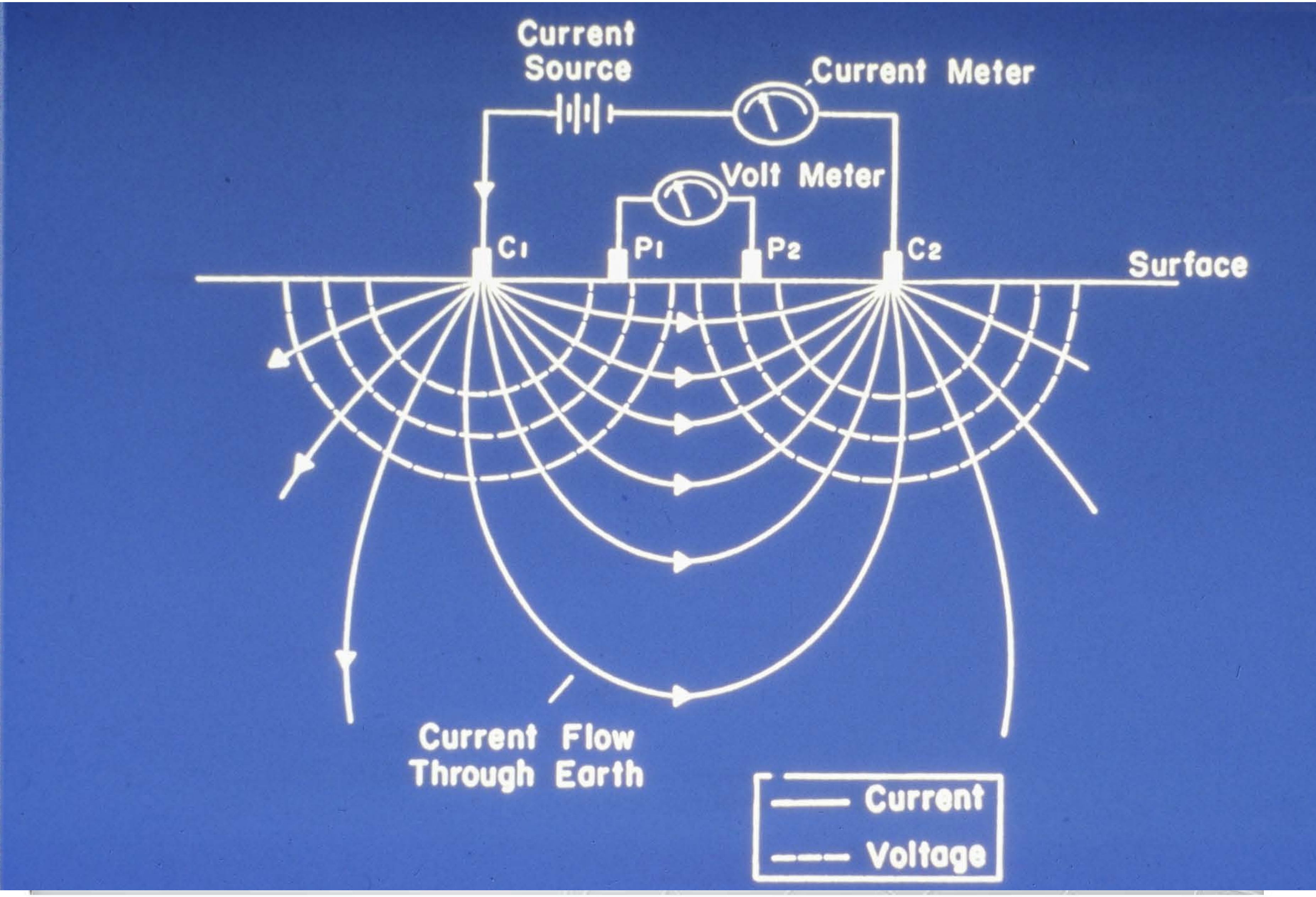
SURFACE GEOPHYSICAL SURVEYS

- Can be useful for delineating source areas
- Assessment of geologic and hydrogeologic conditions
- Delineation of contaminant plumes
- Use caution – methods are subject to sources of interference and data outputs are subject to interpretative errors

TYPES OF SURFACE GEOPHYSICAL TECHNOLOGIES

- Resistivity
- Electromagnetic conductivity
- Magnetometer surveys
- Ground penetrating radar
- Seismic refraction and reflection surveys


Current
Source
Current Meter
Volt Meter
C1
P1
P2
C2
Surface
Current Flow
Through Earth
Current
Voltage

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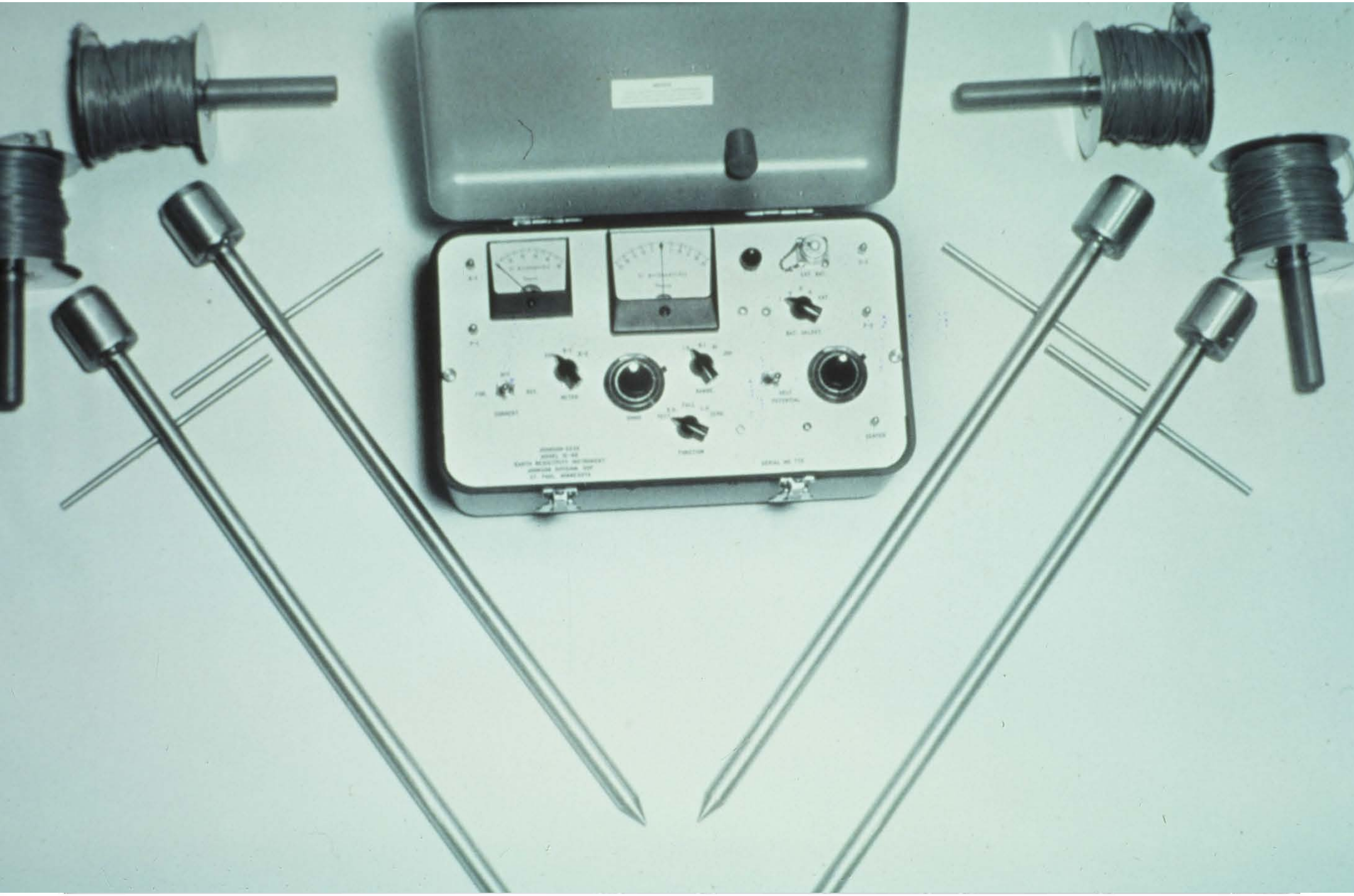

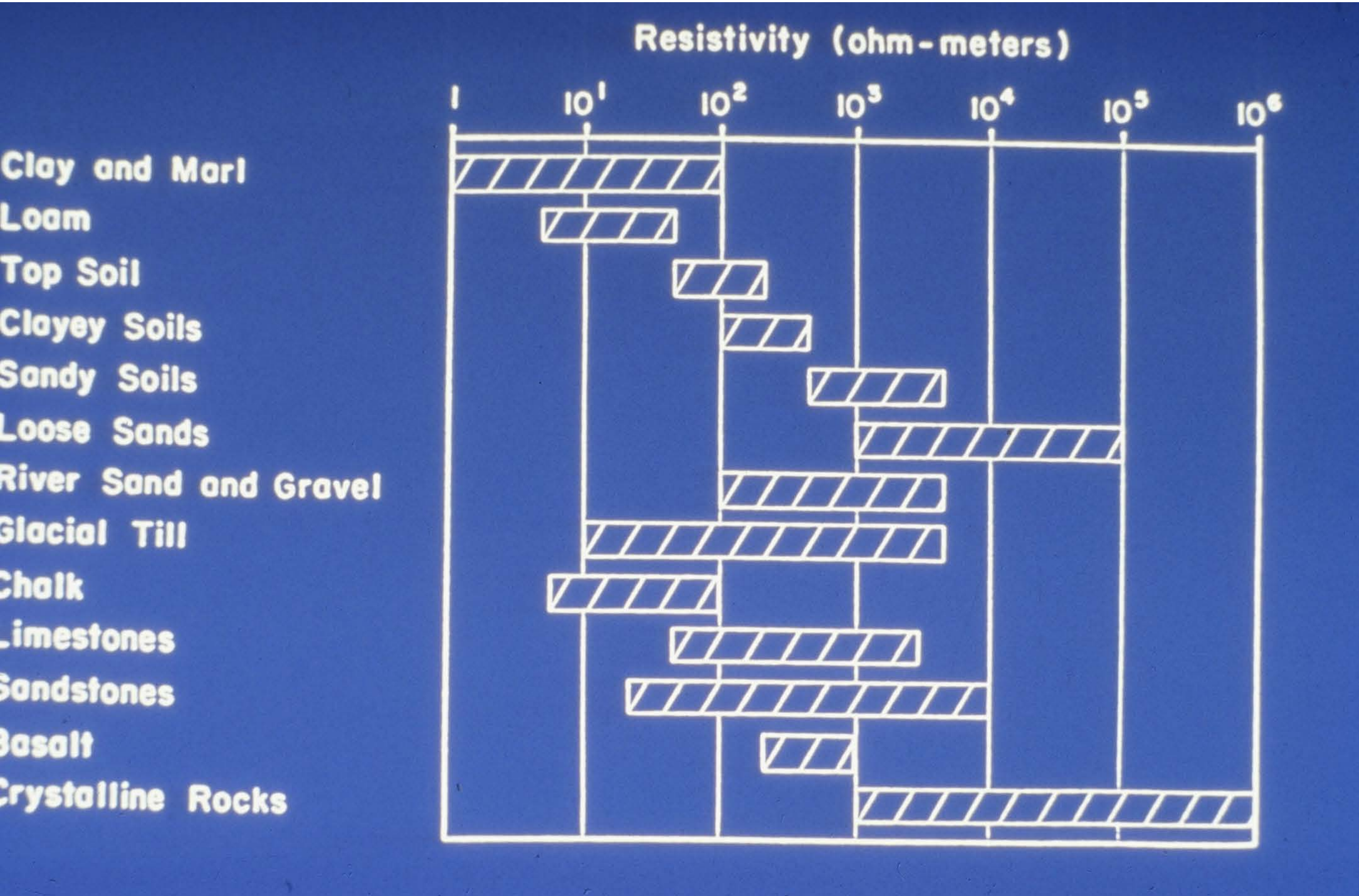
Resistivity (ohm-meters)
1
10¹
10²
10³
10⁴
10⁵
10⁶
Clay and Marl
Loam
Top Soil
Clayey Soils
Sandy Soils
Loose Sands
River Sand and Gravel
Glacial Till
Chalk
Limestones
Sandstones
Basalt
Crystalline Rocks


TNT Bestway Transportation
TNT Bestway Transportation
BestWay Transportation

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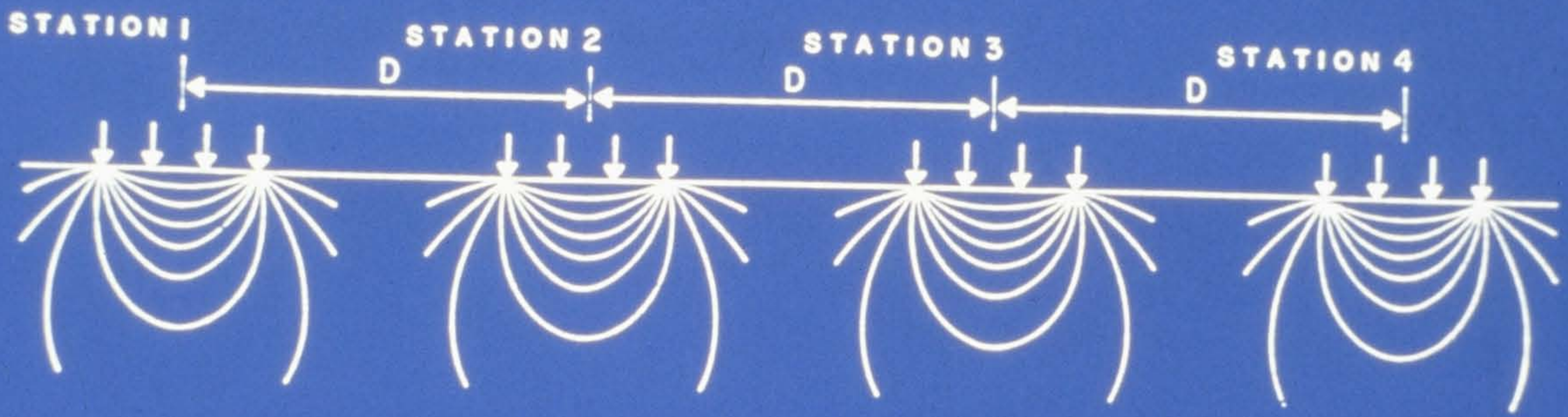
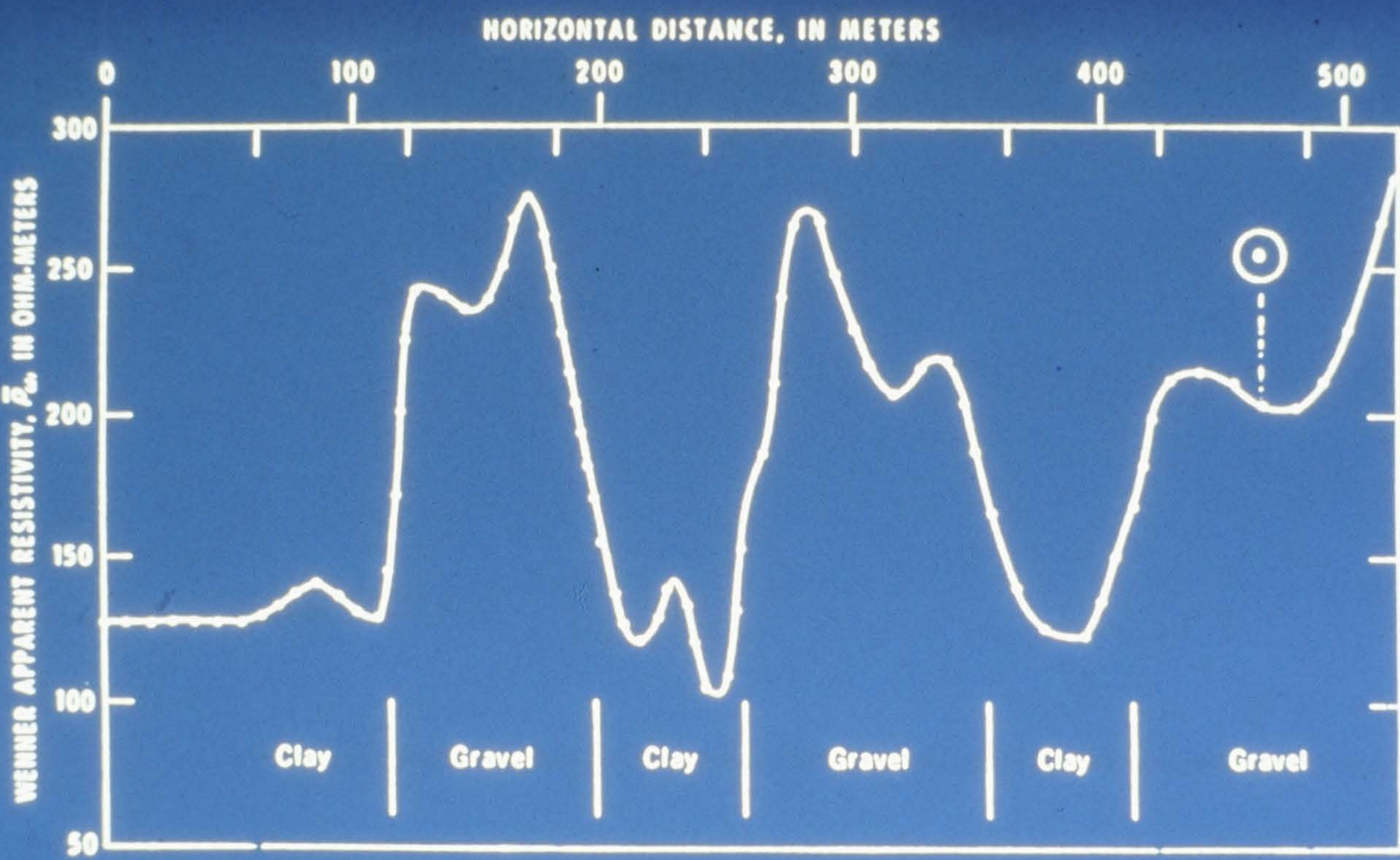

STATION 1
STATION 2
STATION 3
STATION 4
D
D
D



Resistivity profile across glacial clays and gravels.

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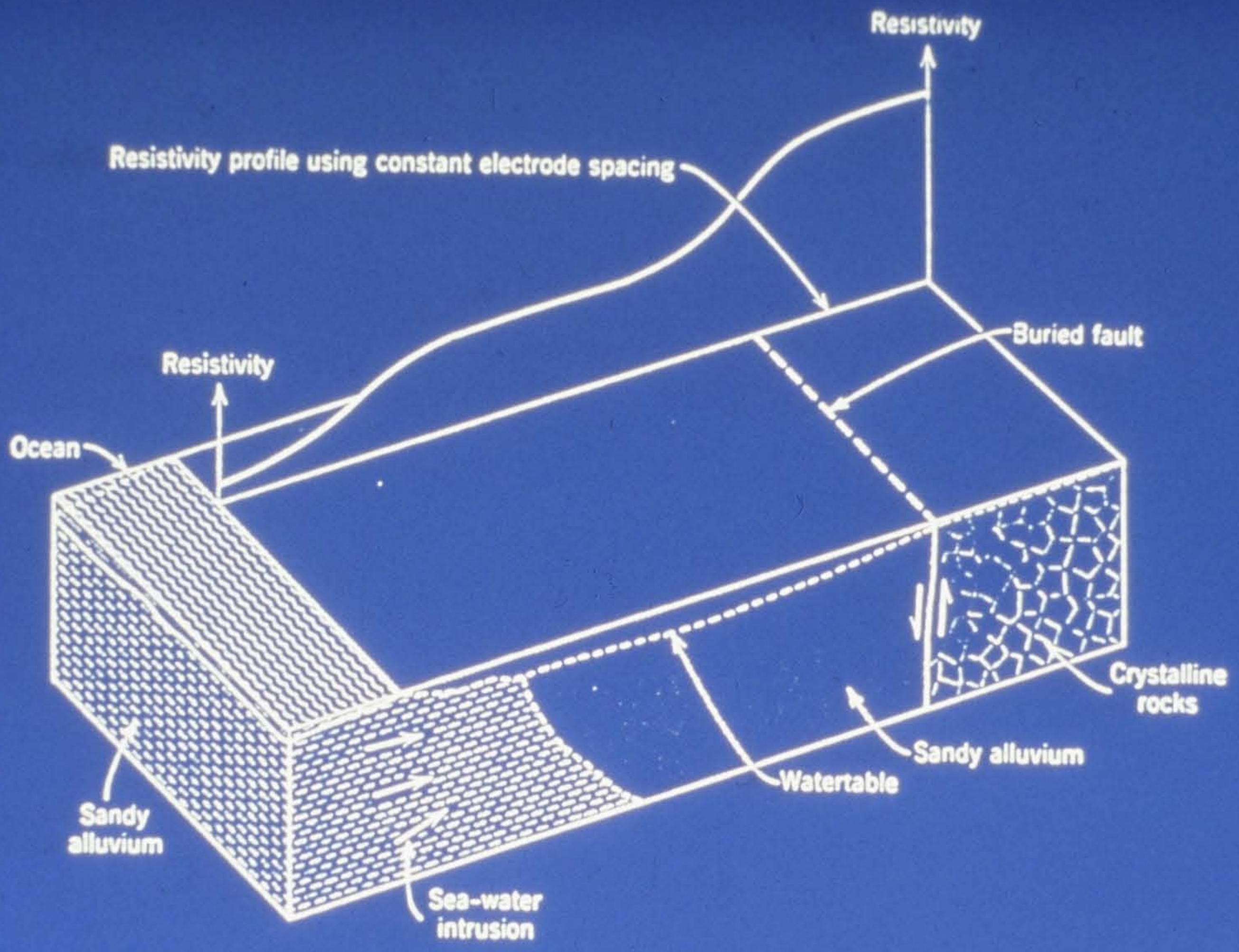
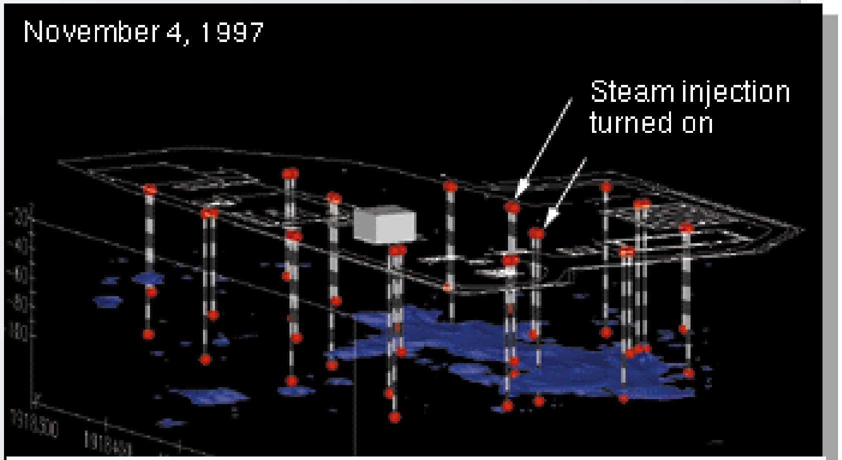


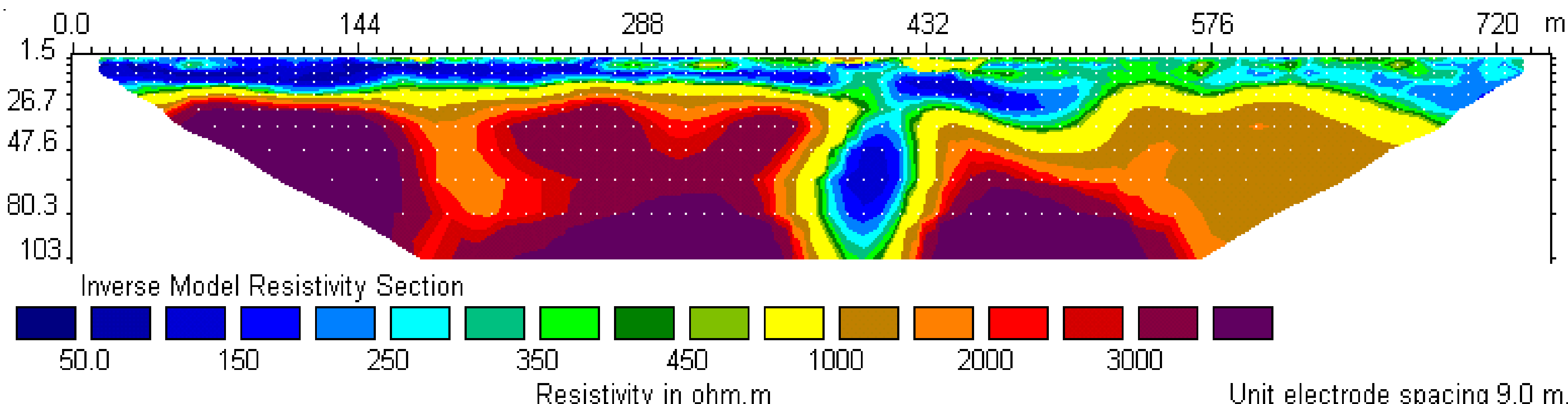
The use of a resistivity profile to locate the extent of sea-water intrusion into a homogeneous sandy aquifer. A fault is also located inland by the same profile.

ELECTRICAL RESISTIVITY

- Measures resistivity of subsurface including effects of soil type (clay content), bedrock fractures, contaminants, and groundwater
- Used to delineate stratigraphy, infer depth to water table, locate fractures and faults, identify karst features, etc.
- Electric resistance tomography (ERT), using cross-hole electrode arrays



Resistivity increases used to track steam injection at Visalia wood-treating site
Source: SteamTech and www.llnl.gov

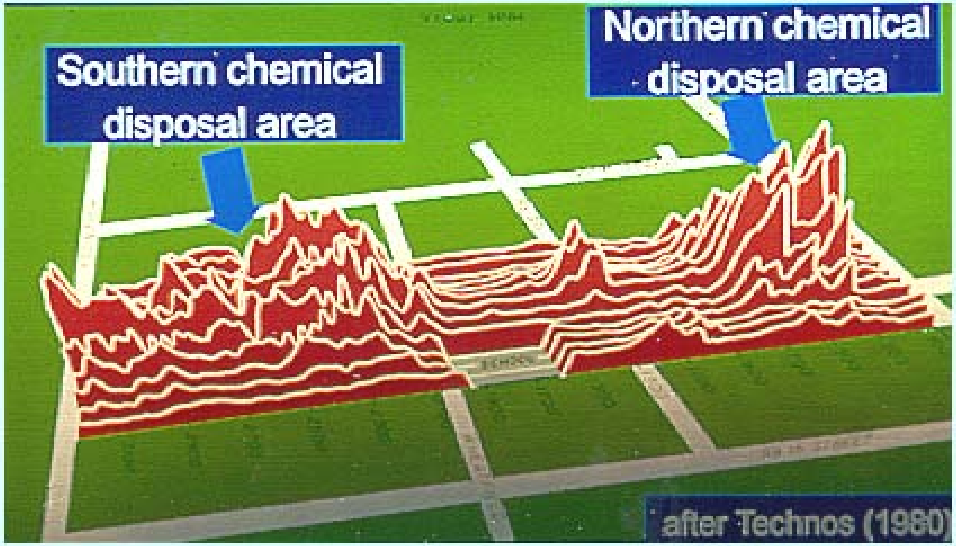


Electromagnetic (EM) Conductivity

- Measures bulk electrical conductance by recording changes in induced EM currents
- Used to infer presence of conductive contaminants, buried wastes, and stratigraphy
- Station measurements, depth depends on transmitter-receiver spacing

Source: Geonics, 1999

Source: Geonics, 1999



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METAL DETECTOR SURVEYS

- Can be used to identify ferrous and non-ferrous buried material
- Can be used to locate drums, tanks, and buried pipes
- Quick and inexpensive

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MAGNETOMETER SURVEYS

- Measures the intensity of the earth’s magnetic field
- Can be used to observe relative change in the elevation of the bedrock surface
- Can identify buried ferrous metallic objects
- Total field – measurements taken at specific stations
- Gradiometer – consists of two magnetometers
  - Measures difference in magnetic field intensity between two vertically separated magnetometers
  - Can acquire continuous measurements
  - Responds very well to localized changes in magnetic gradient
  - Better able to detect small objects

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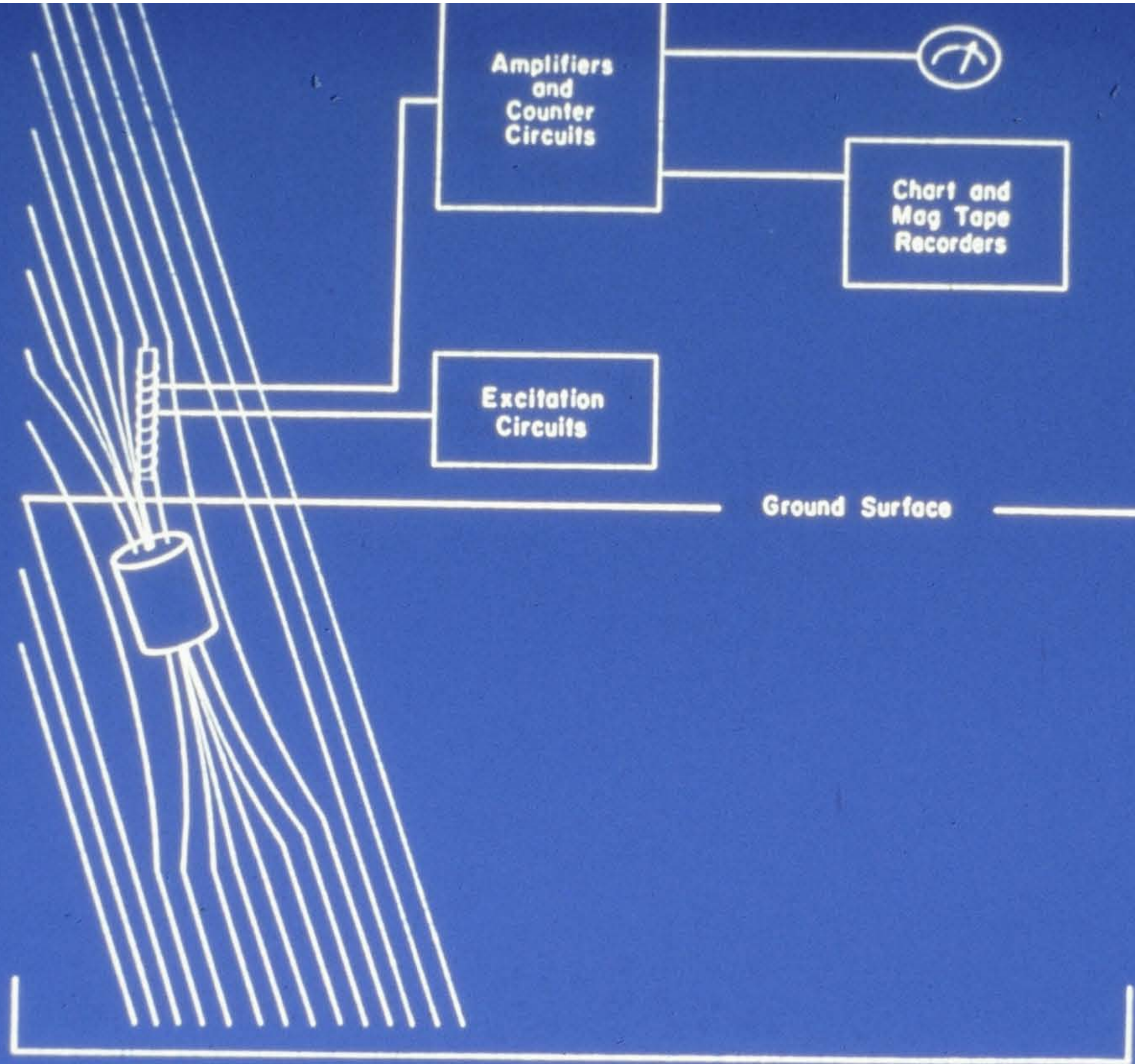

Simplified block diagram of a magnetometer.

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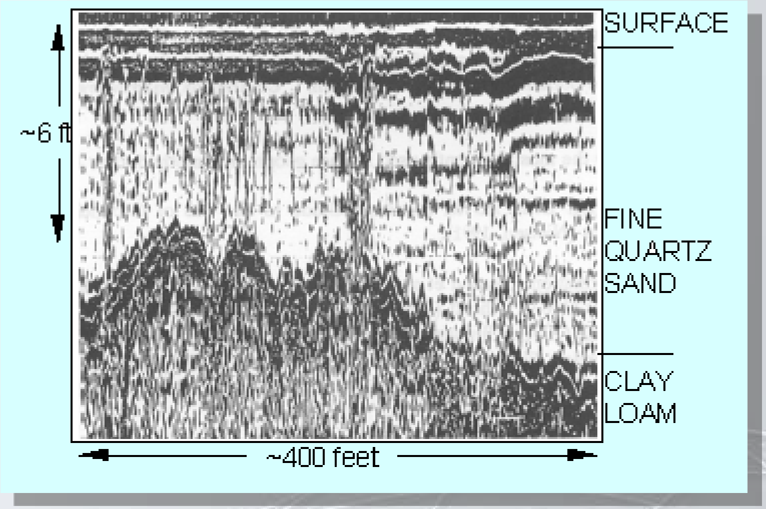
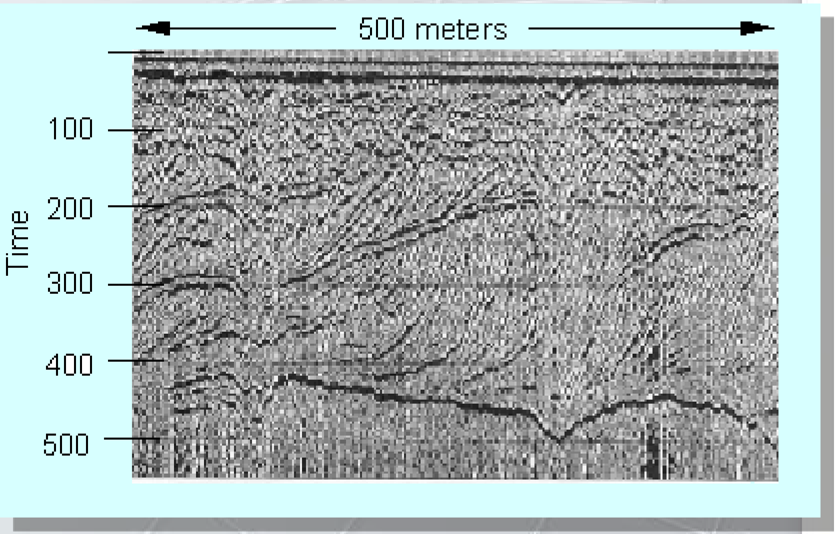
Ground-Penetrating Radar (GPR)

- Measures dielectric and conductivity properties by transmitting EM waves and recording their reflection
- Used to delineate stratigraphy, buried wastes, and utilities in cross section
- Penetration typically 2 to 10 meters bgs – limited by increasing clay content, fluid content, and fluid





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SEISMIC SURVEYS

- Can delineate subsurface stratigraphy and structure
- Depth to water table
- Areas of buried waste
- Buried alluvial channels

SEISMIC REFRACTION SURVEYS

- Can be used for shallow investigations, up to depths of a few hundred meters
- Can readily distinguish 3 or 4 different layers
- Most surveys use 12 to 24 geophones spaced 1 to 3 meters apart
- Two separate pulse sources are used; one from each side of the geophone array
- Limitations
  - Difficult detecting a low velocity layer beneath a high velocity layer
  - Limited ability to identify thin layers of strata

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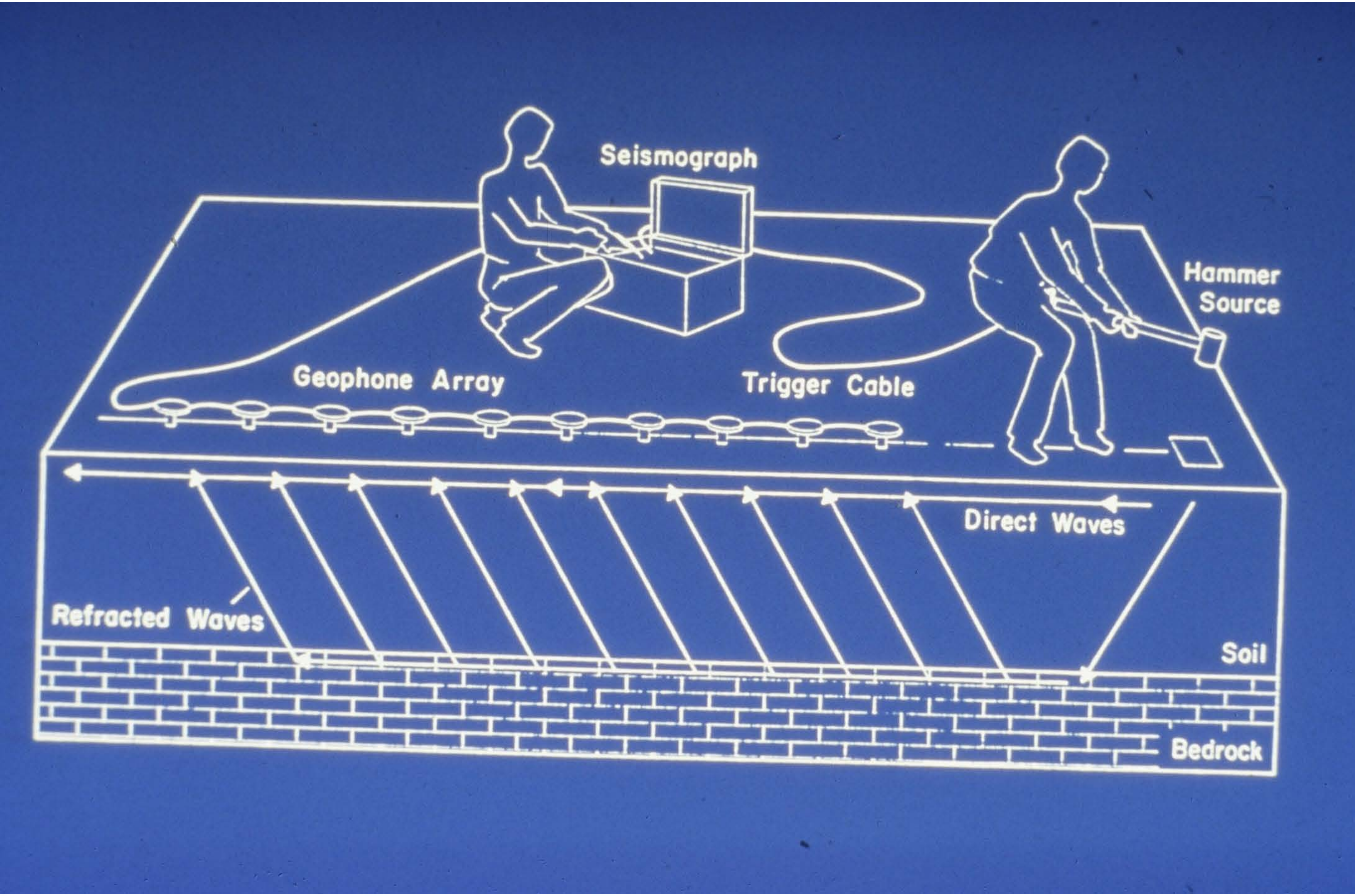
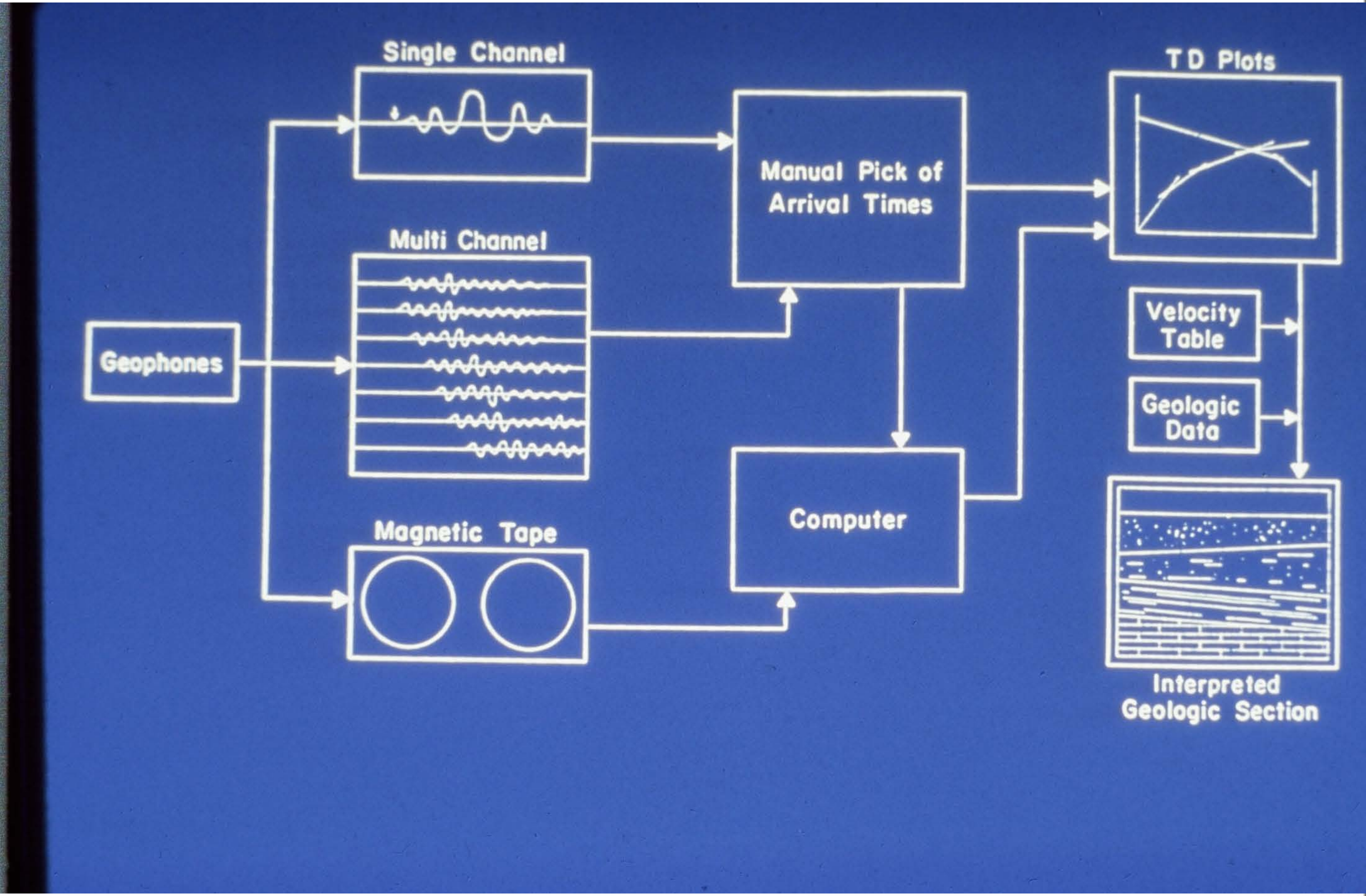

Seismograph
Hammer
Source
Geophone Array
Trigger Cable
Direct Waves
Refracted Waves
Soil
Bedrock


Single Channel
Multi Channel
Magnetic Tape
Geophones
Manual Pick of Arrival Times
Computer
T D Plots
Velocity Table
Geologic Data
Interpreted Geologic Section

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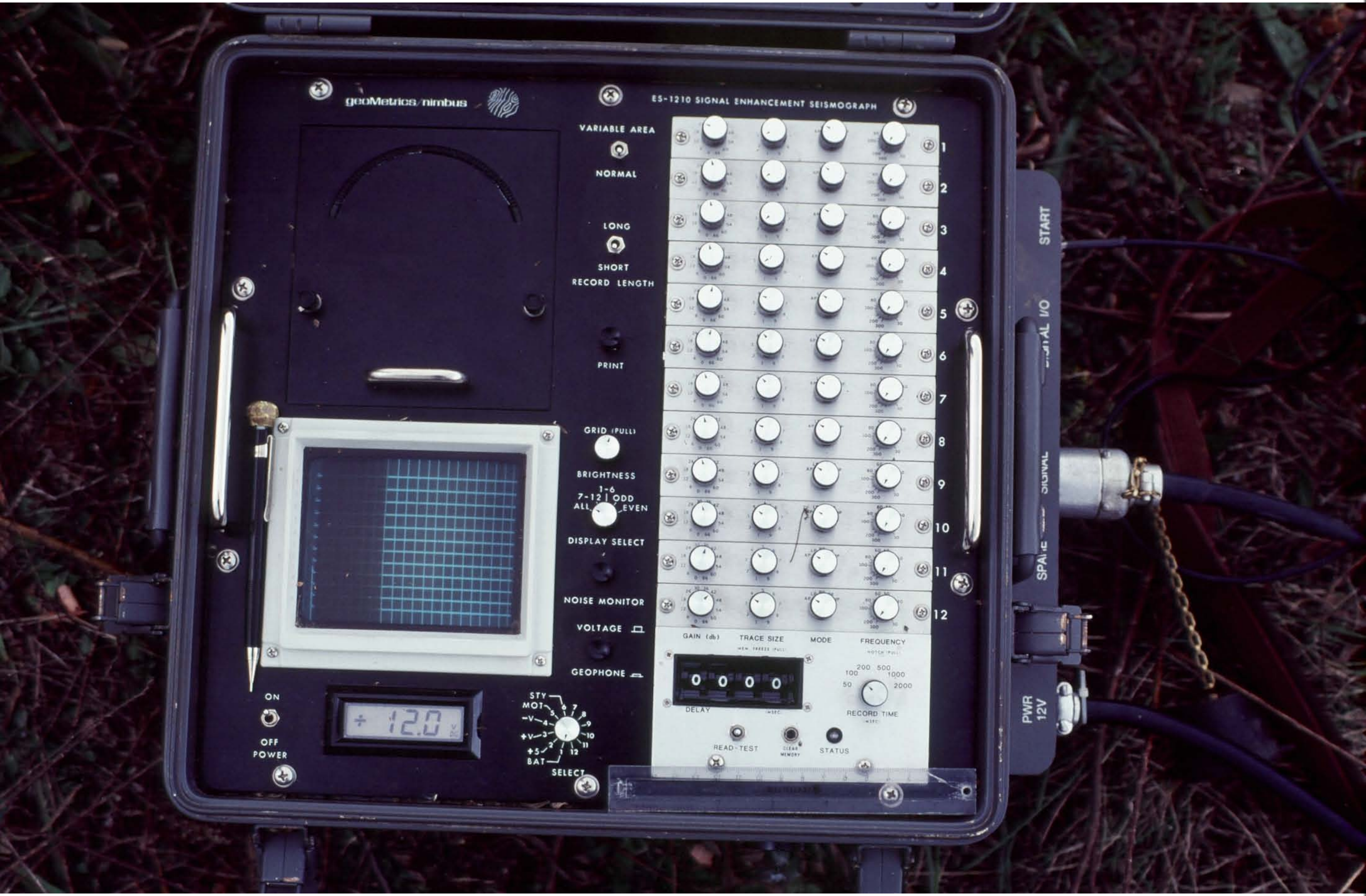
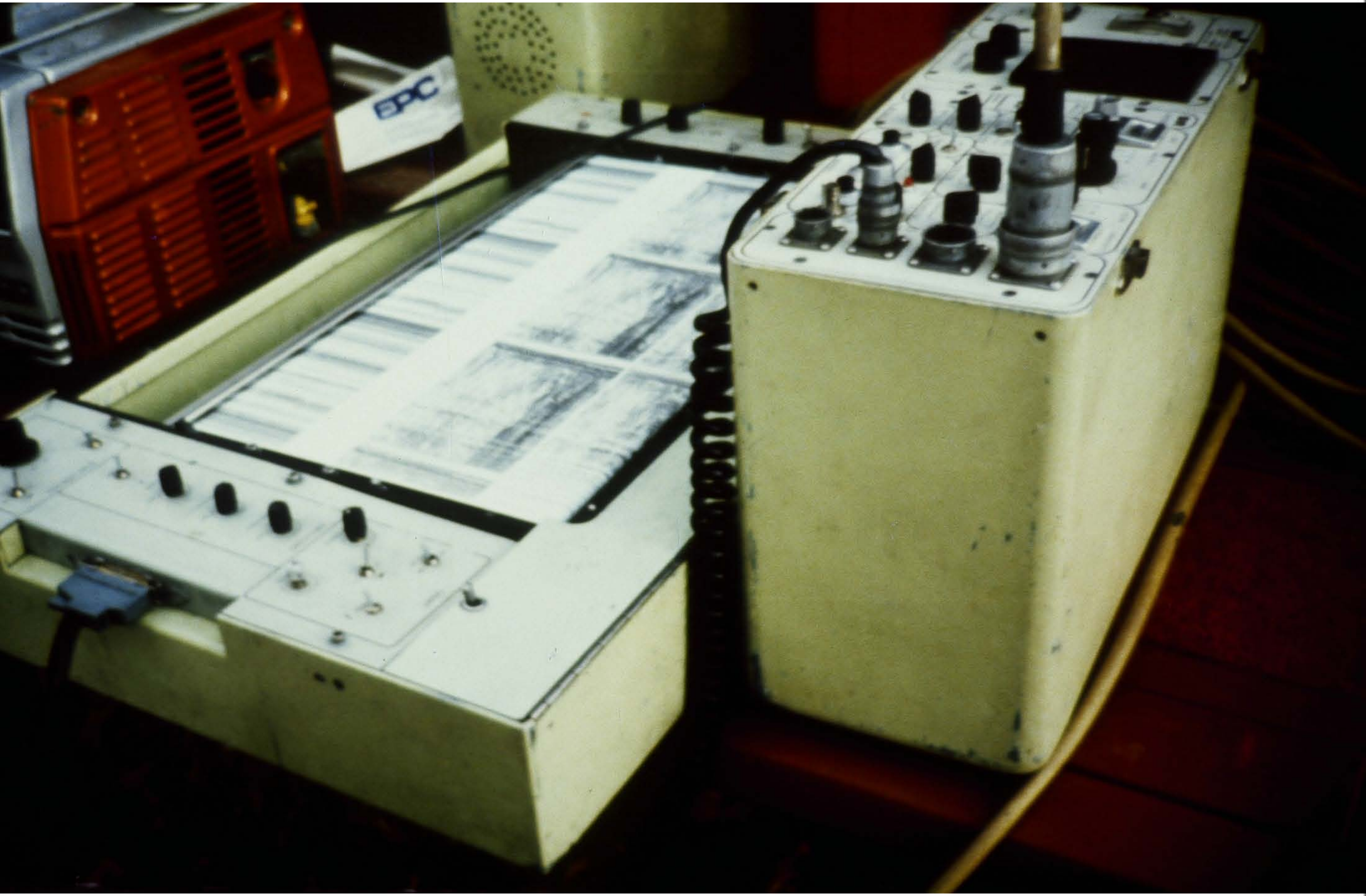

geoMetrics/nimbus
ES-1210 SIGNAL ENHANCEMENT SEISMOGRAPH
VARIABLE AREA
NORMAL
LONG
SHORT
RECORD LENGTH
PRINT
GRID (PULL)
BRIGHTNESS
1-6
7-12 ODD
ALL EVEN
DISPLAY SELECT
NOISE MONITOR
VOLTAGE
GEOPHONE
ON
OFF
POWER
12.0
STY
MOT
-V
+V
+5
BAT
SELECT
1
2
3
4
5
6
7
8
9
10
11
12
GAIN (db)
TRACE SIZE
MODE
FREQUENCY
0 0 0 0
DELAY
50
100
200
500
1000
2000
RECORD TIME
READ-TEST
STATUS
START
SIGNAL
SPARE
PWR
12V



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SEISMIC REFLECTION SURVEYS

- Most commonly used for surveys from 10 meters to 30 meters deep
- Typically can utilize a smaller energy pulse than a refraction survey

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DATA FROM NON-INTRUSIVE TECHNOLOGIES SHOULD BE:

- Used to refine the Conceptual Site Model to enable more focused intrusive investigations
- Select locations to sample soil and groundwater using intrusive technologies
- Select the most appropriate intrusive investigation technologies to achieve data objectives

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QUESTIONS?