

# **Integrated Surface and Borehole Strong-Motion, Soil-Response Arrays in San Francisco, California**

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**Menlo Park, CA**  
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## Presentation Outline

- **General Design Objectives**
- **Geotechnical Site Characteristics**
- **Array Design ( Instrumentation)**
- **Anelastic Wave-Field Characteristics**

# Damage from 1906 Earthquake and Fire in San Francisco, CA

Harrison and Sixth

Market Street



Photo G. Lawrence, 1906

# Locations of Integrated Soil- and Structural- Response Arrays in San Francisco, CA

Bessie Charmichael School

Chevron Building

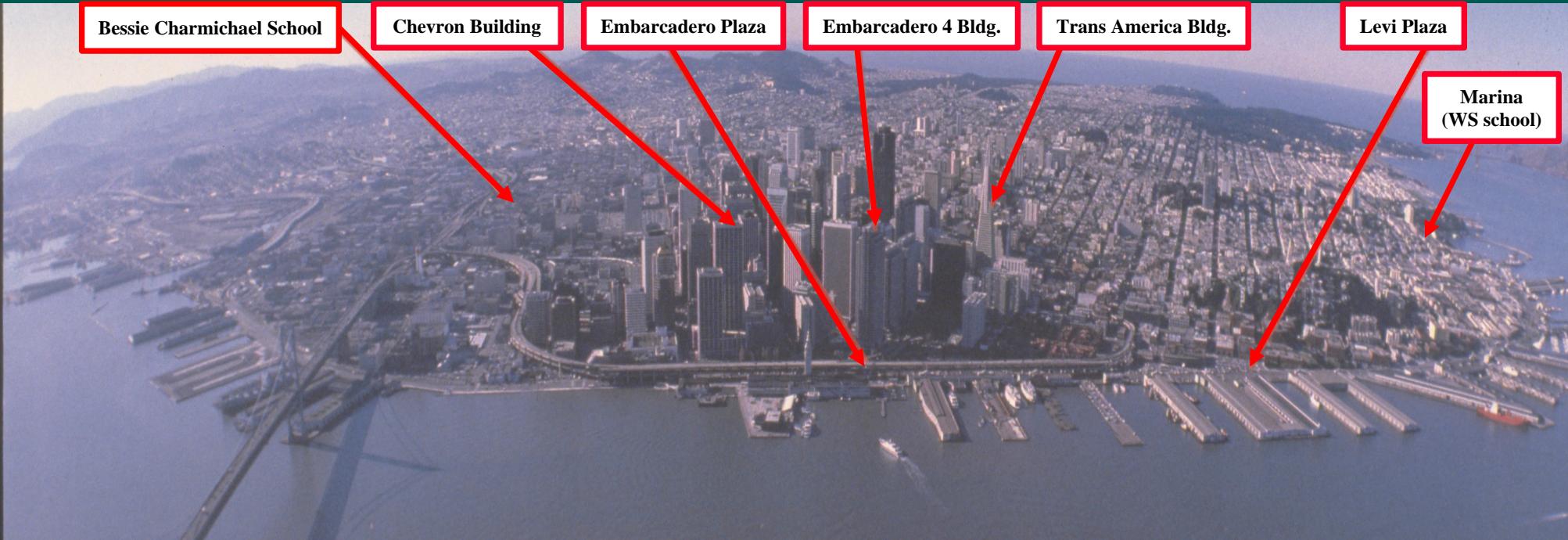
Embarcadero Plaza

Embarcadero 4 Bldg.

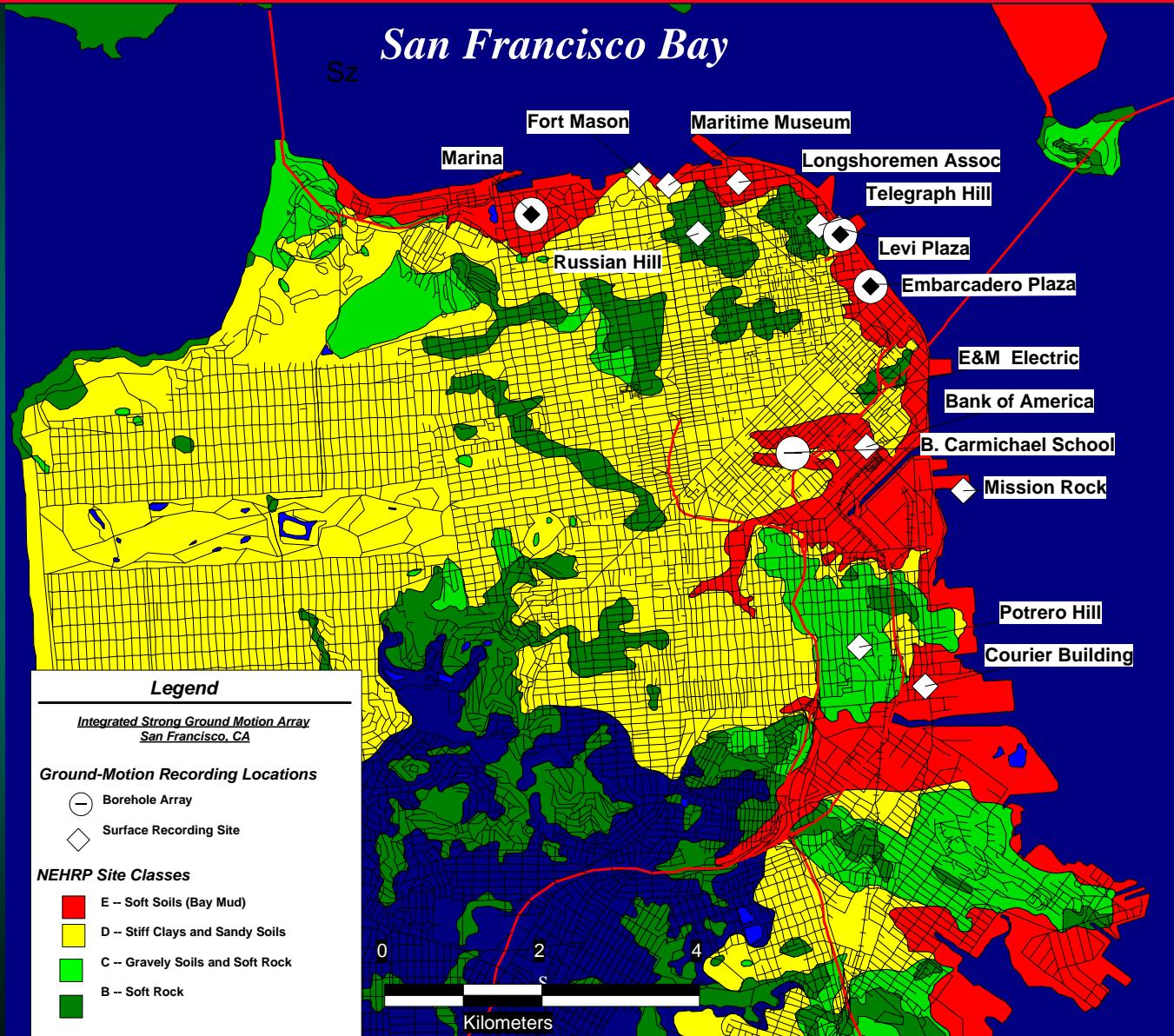
Trans America Bldg.

Levi Plaza

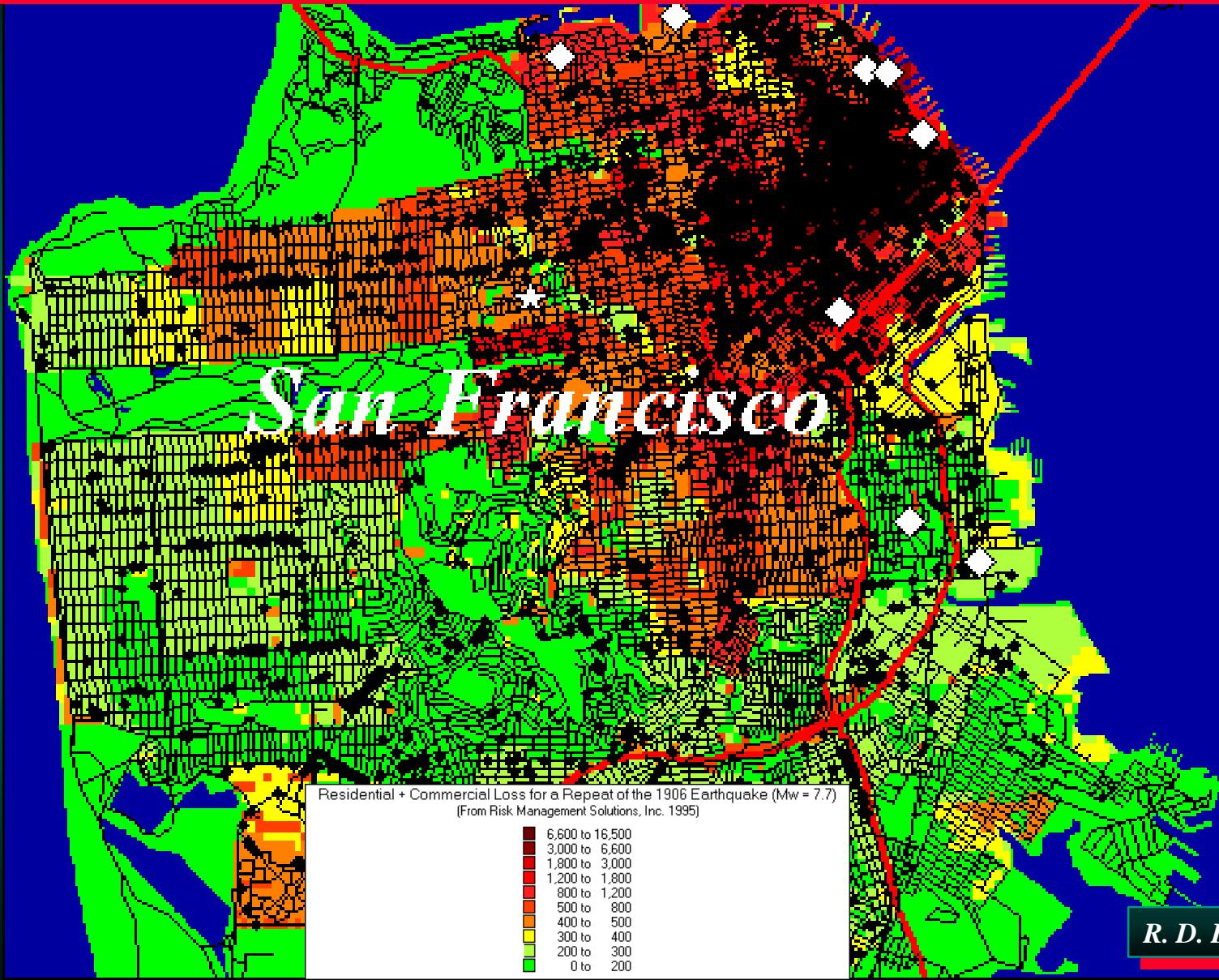
Marina  
(WS school)



# Locations of Integrated Surface and Borehole Strong-Motion Arrays in San Francisco, CA



# Estimated Losses for a Repeat of the 1906 Earthquake in San Francisco, CA



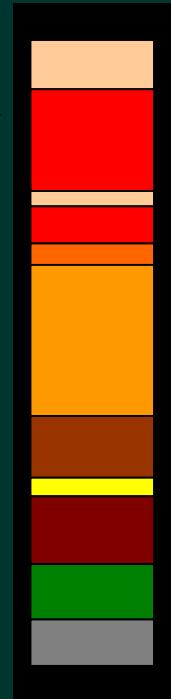
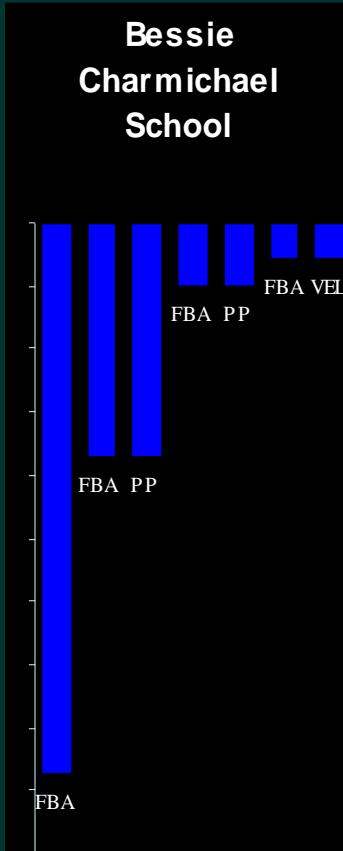
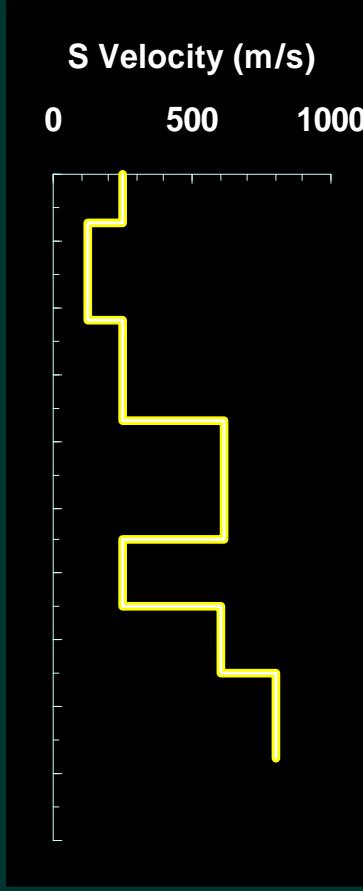
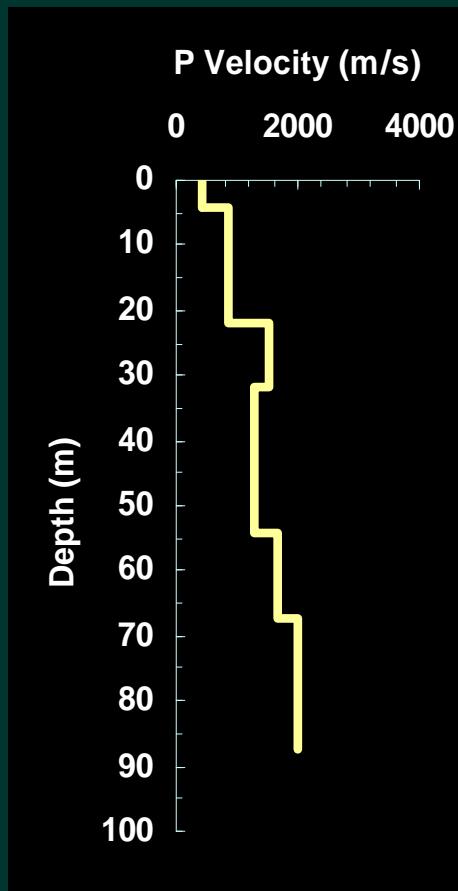
# Location of Borehole Array at Bessie Charmichael School San Francisco, CA

Bessie Charmichael School



*R. D. Borchardt*

# Seismic and Geologic Logs for Array at Bessie Charmichael School



- Sand (Fill)
- Holocene Clay, Silty Clay
- Sand
- Clay
- Sandy Clay, Loam
- Sand to sandy loam
- Clay (v. stiff to hard)
- Gravelly Sand
- Clay (hard)
- Serpentine
- Shale

# Location of Borehole Array and Nearby Well-Instrumented Buildings near Embarcadero Plaza San Francisco, CA

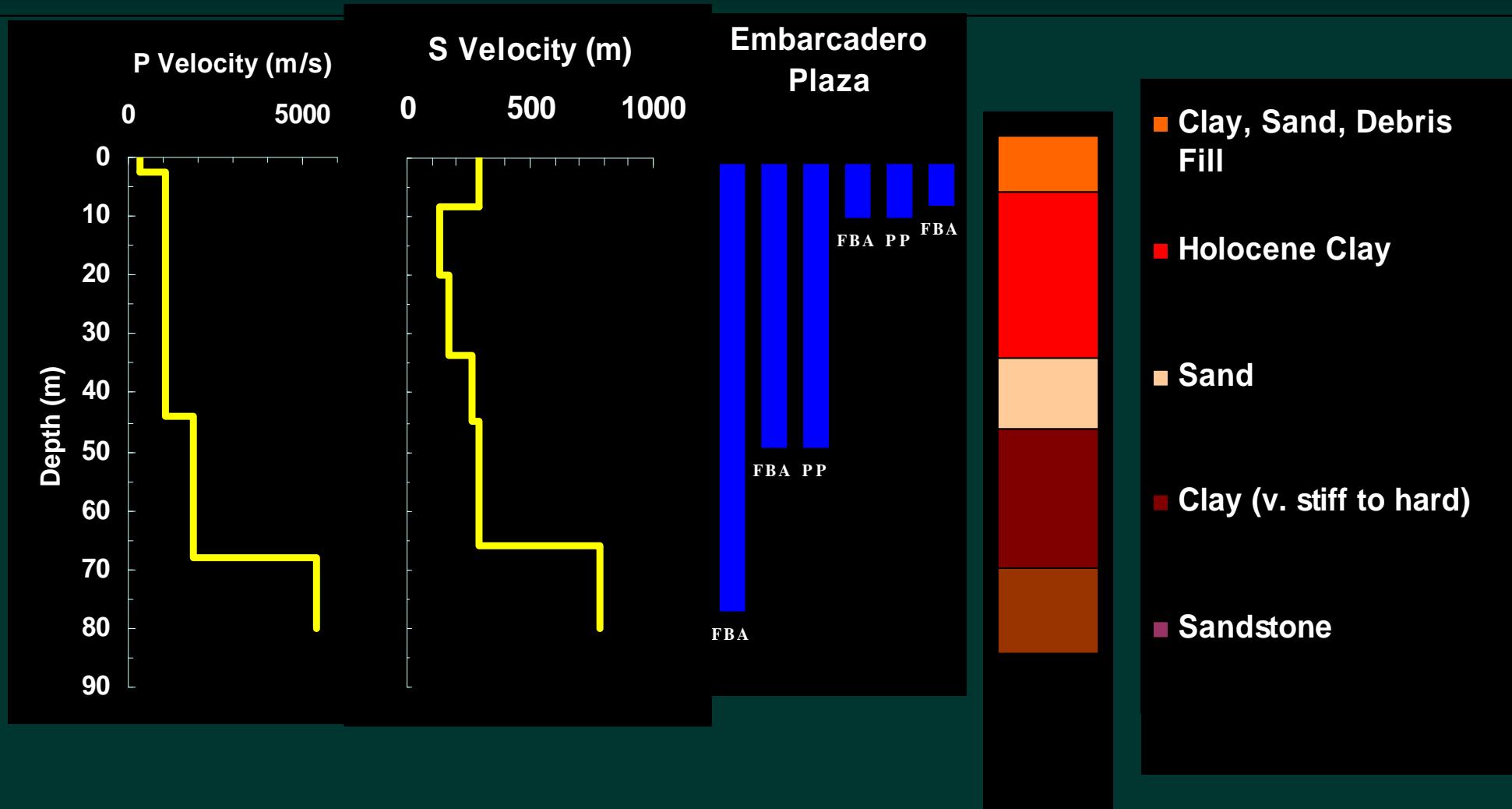


Trans America (USGS)

Embarcadero Four (CDMG)

Embarcadero Plaza Array (USGS)

# Seismic and Geologic Logs for Array at Embarcadero Plaza



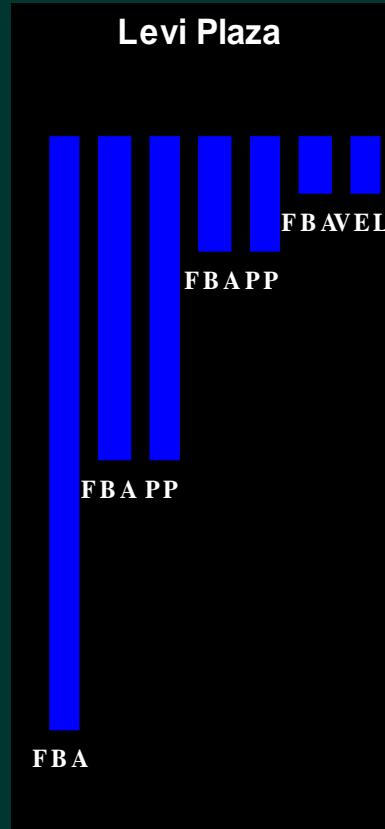
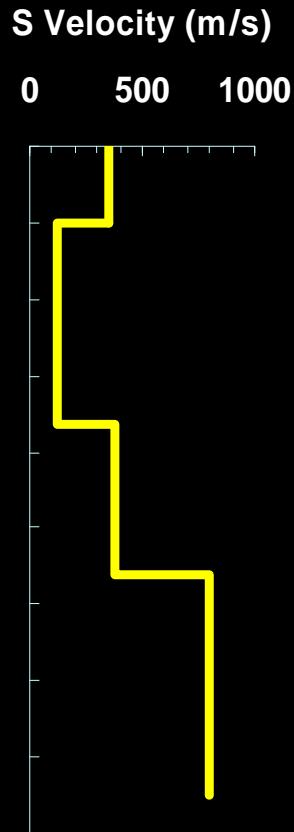
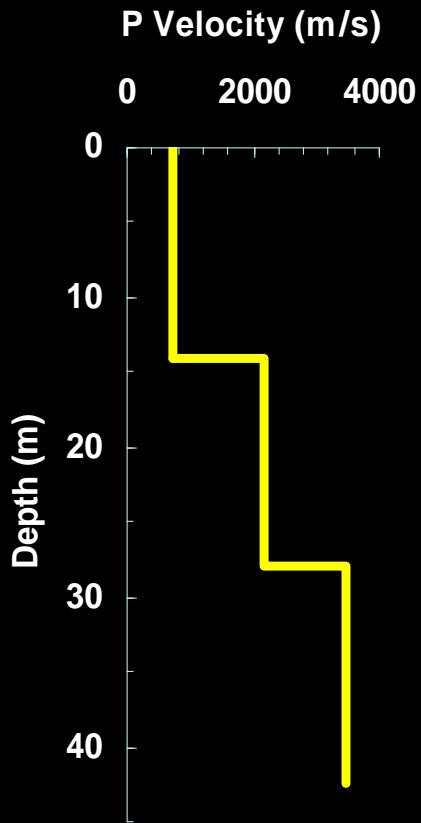
# Location of Borehole Array and Surface Recorder on Rock near Levi Plaza San Francisco, CA



Telegraph Hill

Levi Plaza

# Seismic and Geologic Logs for Array at Levi Plaza



- Gravelly Sand (Fill)
- Holocene Clay
- Shelly Clay
- Dense Sand w Clay Layers
- Sandy Clay
- Shale

# Locations Near Marina Array in San Francisco, CA

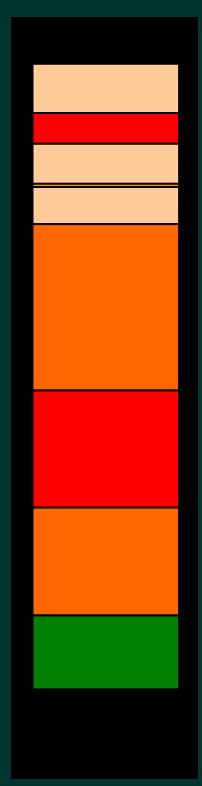
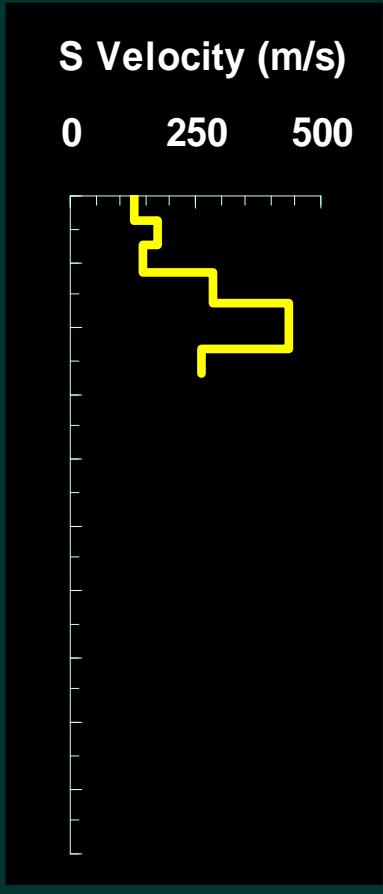
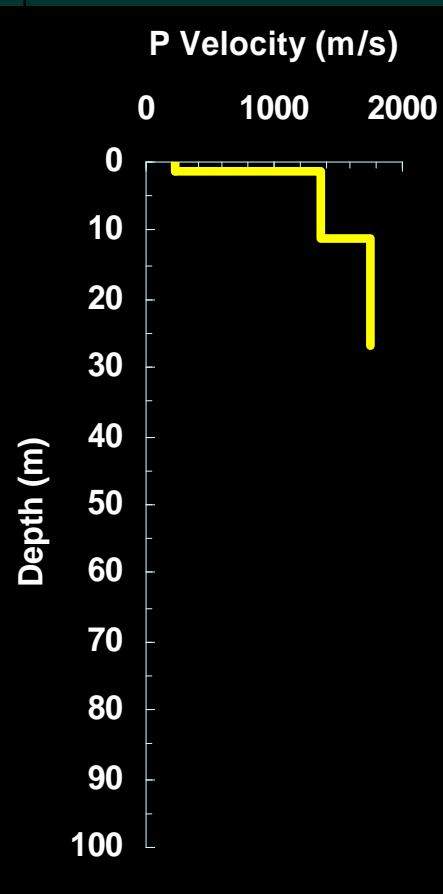
**Telegraph Hill**

**Fisherman's Warf**

**Marina**



# Seismic and Geologic Logs for Array at Winfield Scott School



- Sand
- Silty Clay
- Sand
- Sandy Clay
- Sand
- Sandy Clay, Silty Clay
- Clay w shells
- Sandy Clay, Silty Clay

# Instrumentation Configuration



GOES  
Satellite



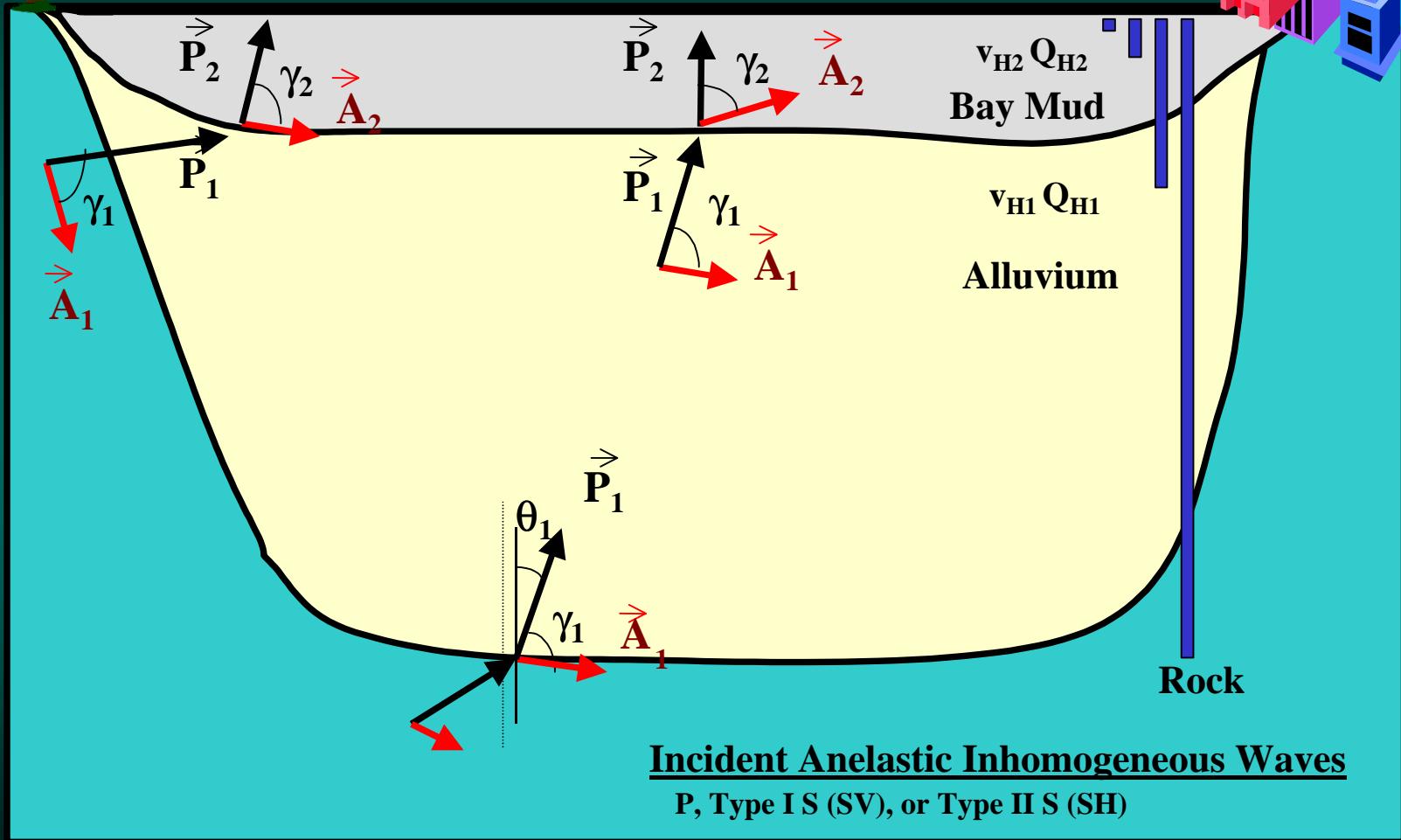
GEOS



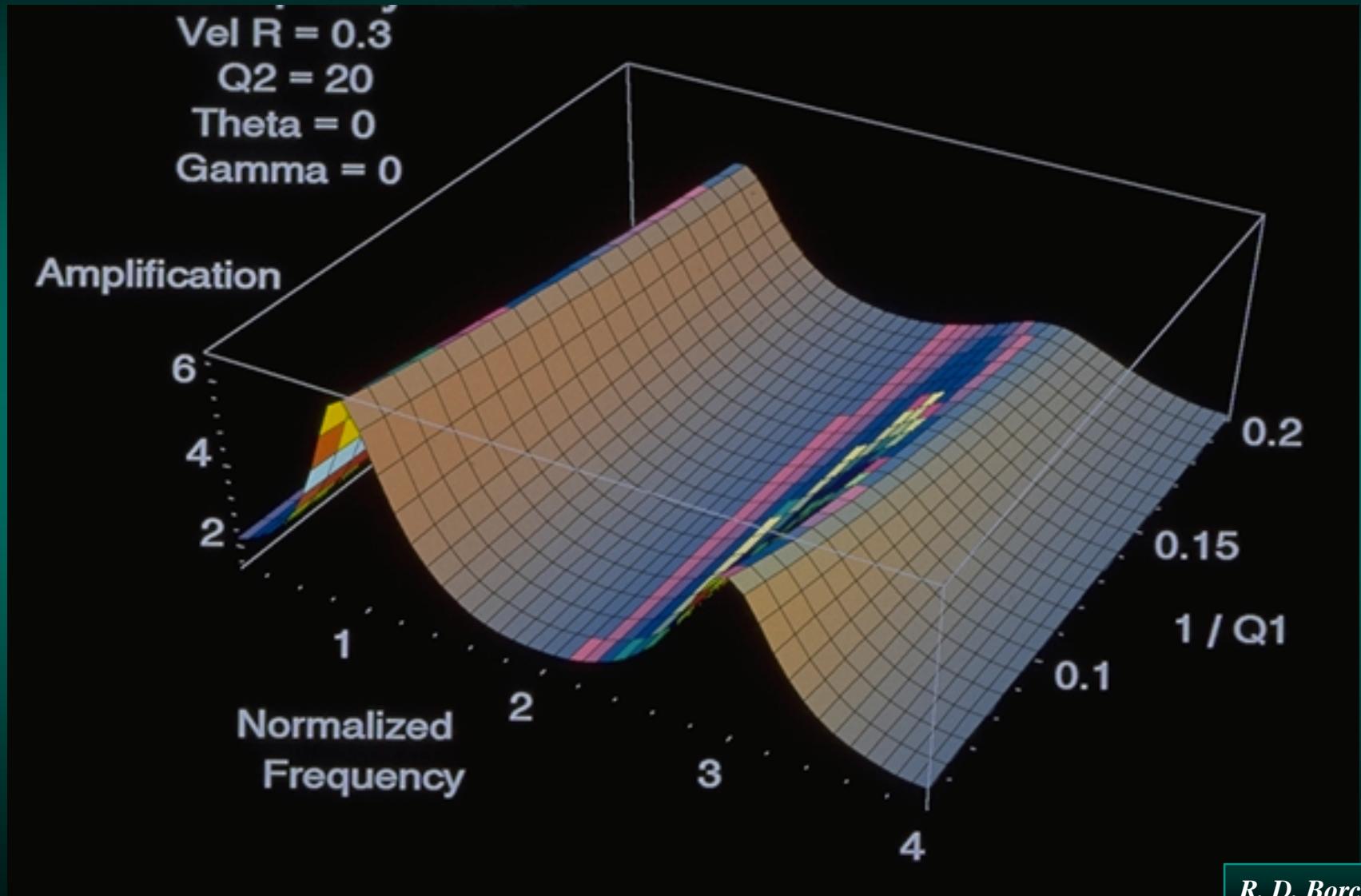
GOES Receiver  
Menlo Park, CA



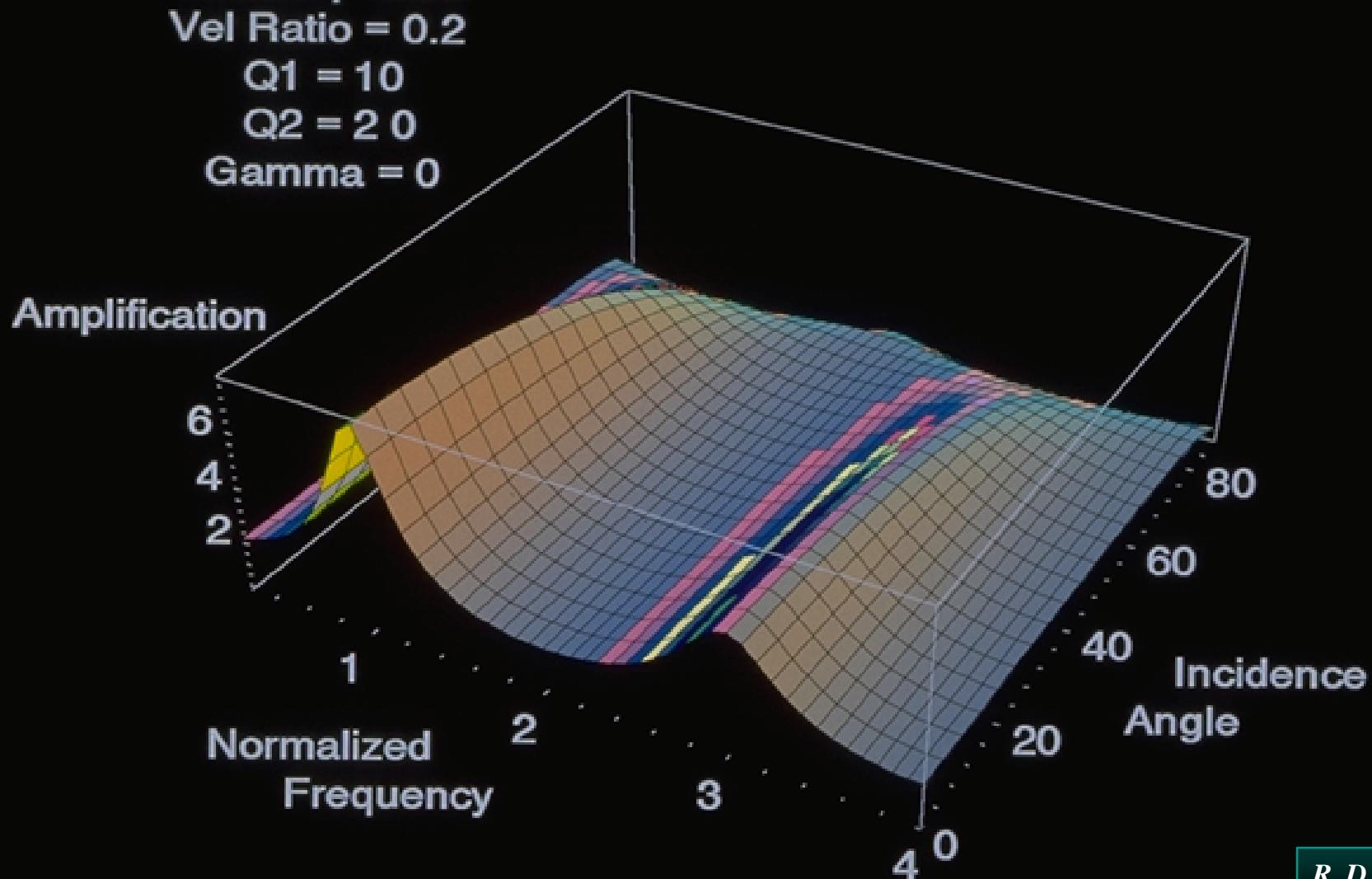
# Body Waves in an Anelastic Basin



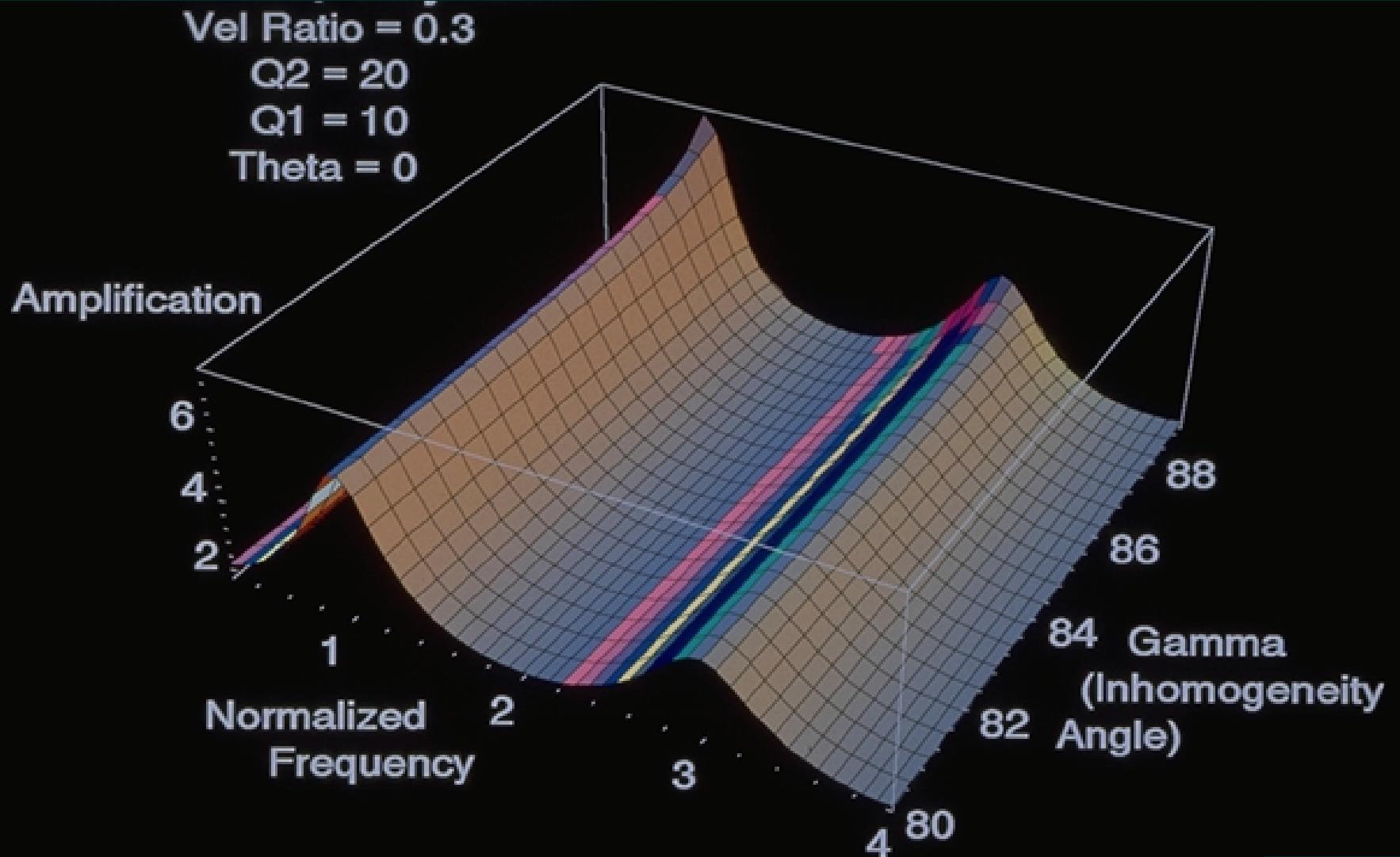
# Anelastic Response for Vertically Incident Homogeneous SH Waves



# Anelastic Response for Incident Homogeneous SH Waves



# Anelastic Response for Vertically Incident Inhomogeneous SH Waves



# Anelastic Response for Incident Inhomogeneous SH Waves

