Earth Fissures and Surface Faults Accompanying Aquifer-System Compaction and Land Subsidence in the USA

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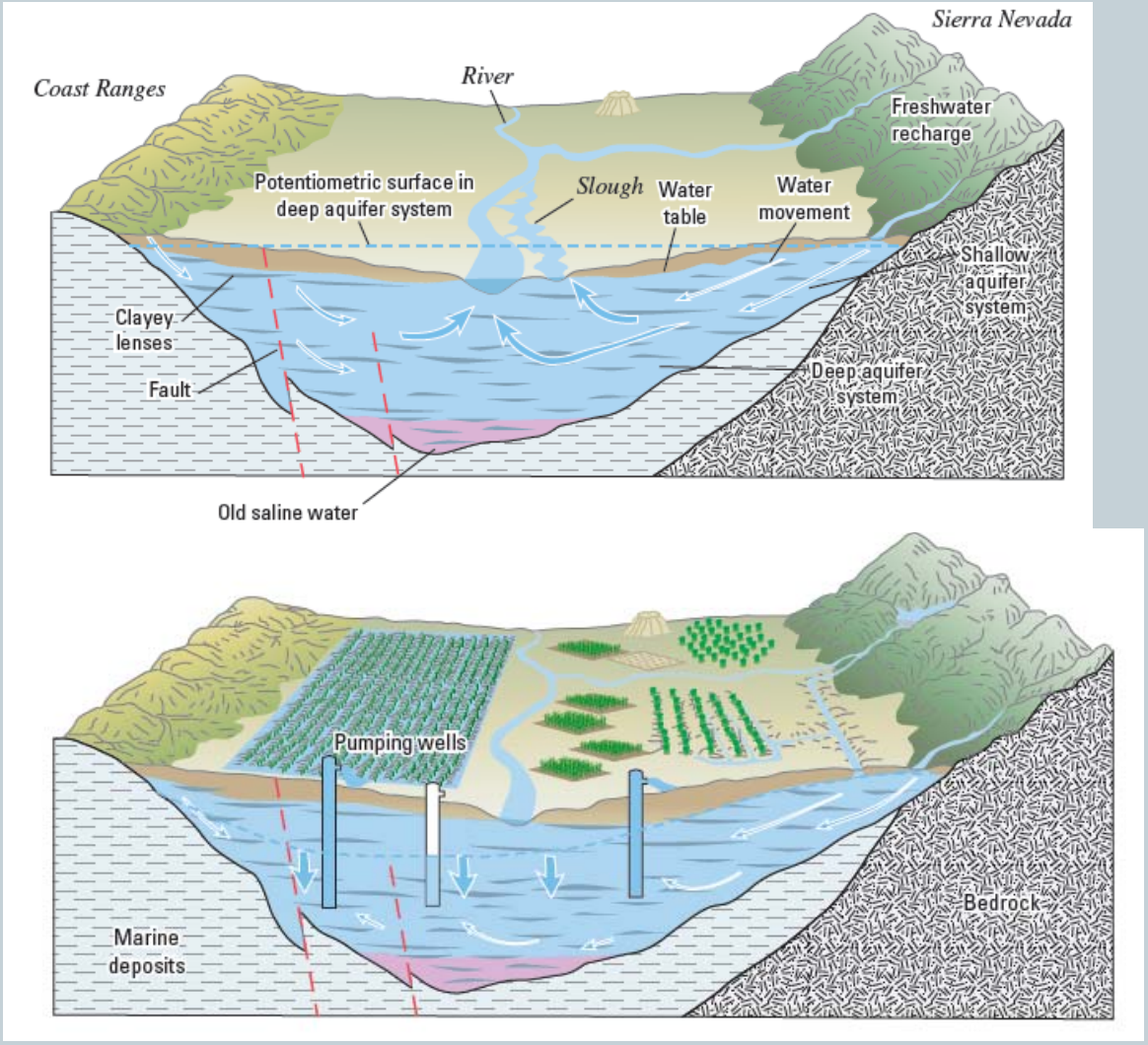
Topics

- Occurrence
  - Susceptible Hydrogeologic Settings
    - Hydrogeologic Framework
    - Land Subsidence/Aquifer-System Compaction
  - Examples
    - Surface Faults
    - Earth Fissures
  - Relation to Subsidence/Subsurface Fluid Extraction
- Site Measurements
  - Surface Faults
  - Earth Fissures

Occurrence

- Susceptible Hydrogeologic Settings
  - Land Subsidence/Aquifer-System Compaction

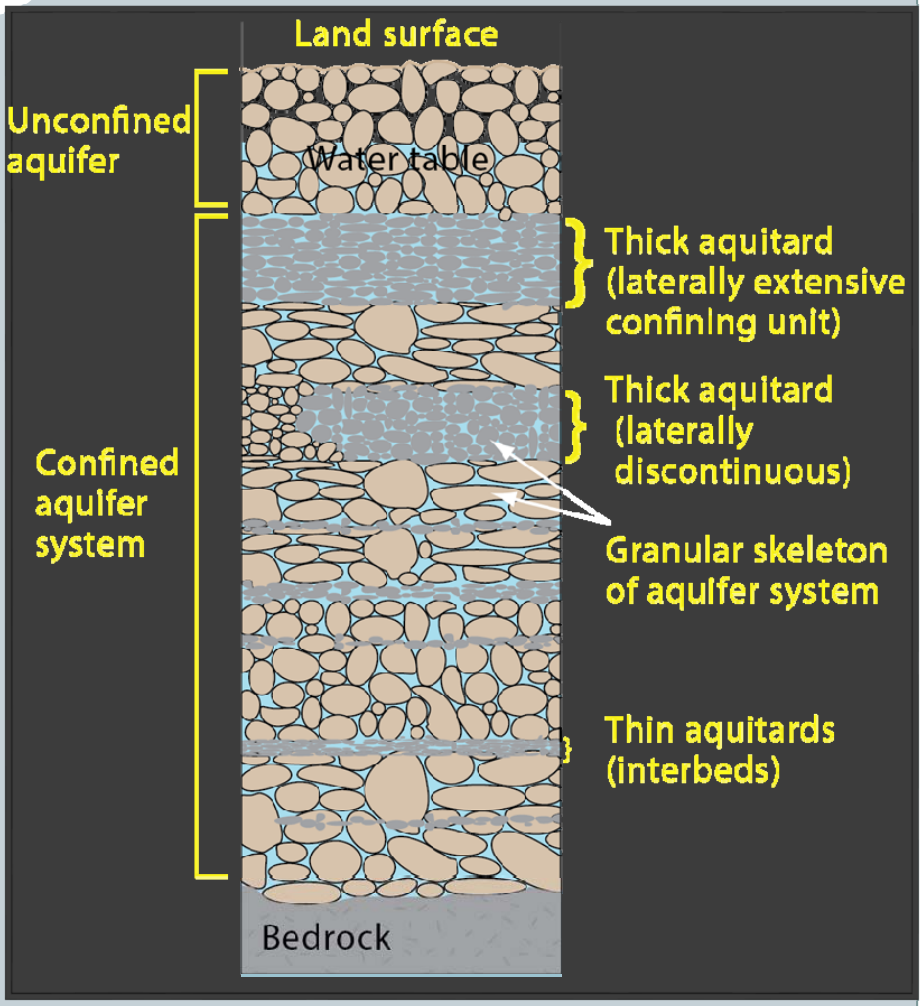
Hydrogeologic Framework—Conceptual Model



Faunt CC (ed) (2009)

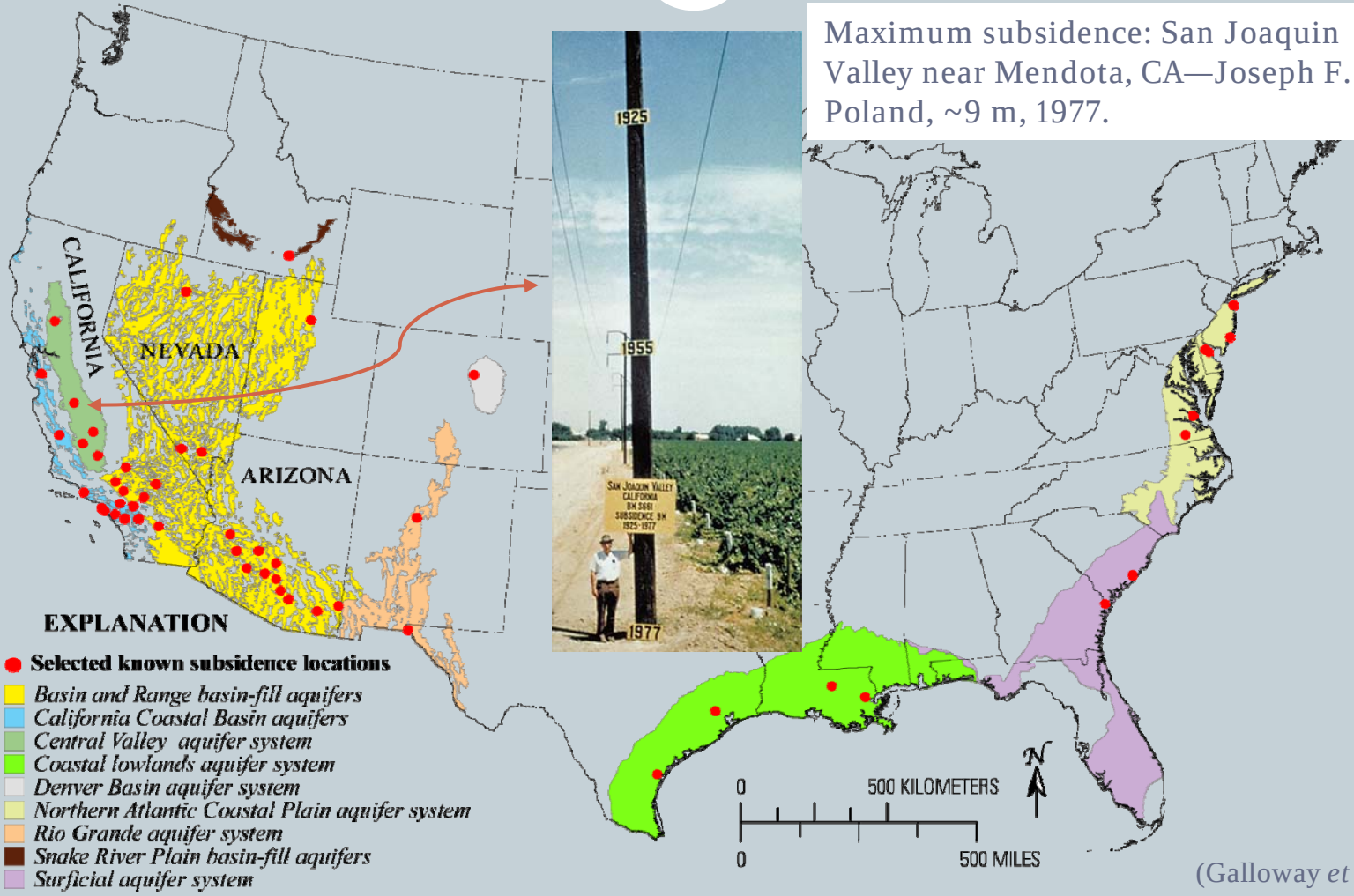
Occurrence

- Susceptible Hydrogeologic Settings
  - Land Subsidence/Aquifer-System Compaction
    - Almost all the permanent subsidence occurs due to the irreversible compression or consolidation of aquitards (interbeds and confining units) during the typically slow process of aquitard drainage (Tolman and Poland, 1940).



Occurrence

- Susceptible Hydrogeologic Settings
  - Land Subsidence/Aquifer-System Compaction



Maximum subsidence: San Joaquin Valley near Mendota, CA—Joseph F. Poland, ~9 m, 1977.

(Galloway *et al.*, 2008)

USGS

Occurrence

- Examples
  - Surface Faults
    - Typically associated with pre-existing faults and land subsidence in at least 5 areas in the western United States (in AZ, CA, TX, NV). The density of faults varies greatly from area to area, but is highest in the greater Houston, Texas subsidence areas.

- Examples
  - Surface Faults/Earth Fissures

Picacho Fault, AZ

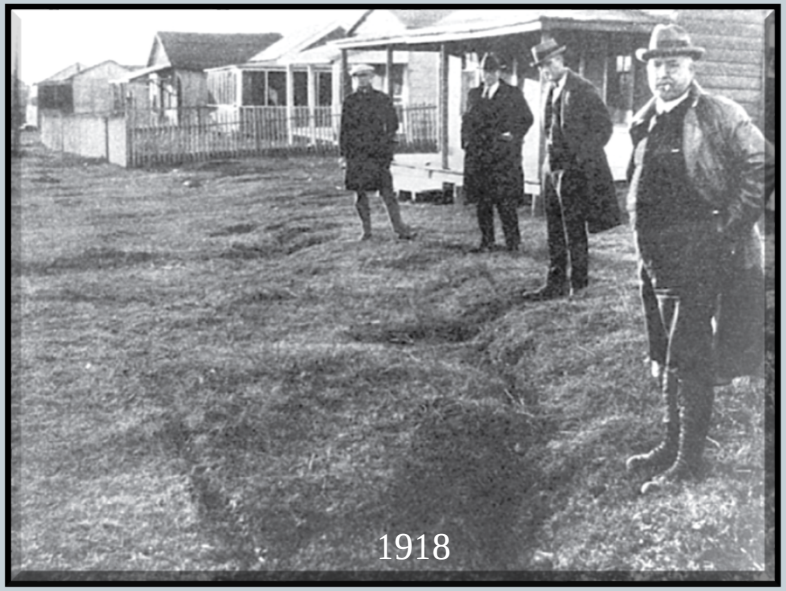
Figure 4. Ground-failure areas in the western United States.

Holzer (1984)

USGS

Occurrence

- Examples
  - Surface Faults – Groundwater/Oil and Gas Extraction



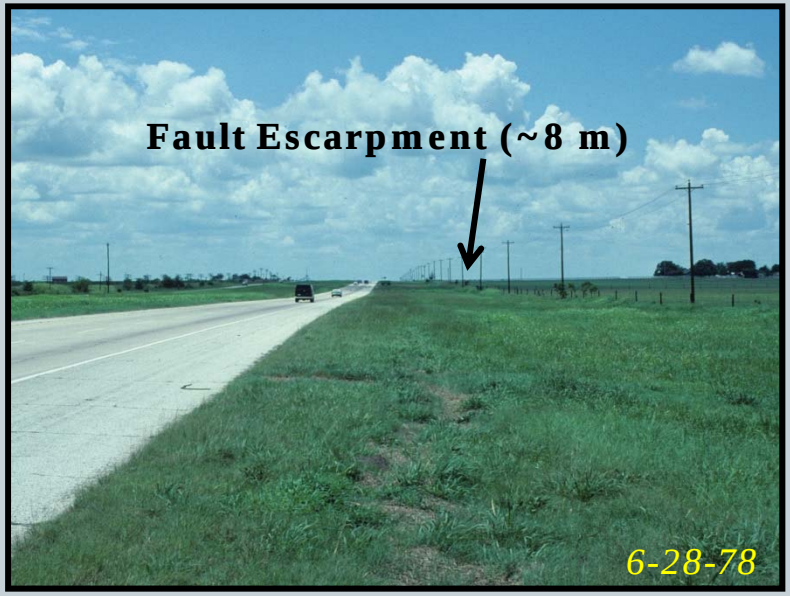
Pratt and Johnson (1926)

Pelley Fault, Goose Creek Oil Field, Houston, TX

Occurrence

- Examples
  - Surface Faults – Groundwater/Oil and Gas Extraction

Ethyl Fault, Houston, TX



Hockley Fault, Houston, TX

Occurrence

- Examples
  - Earth Fissures
    - Large tension cracks—are commonly associated with aquifer-system compaction and subsidence caused by groundwater withdrawal. Occur in many areas in the United States.

Holzer and Galloway (2005)

Eroded Earth Fissure, Fremont Valley, CA

Occurrence

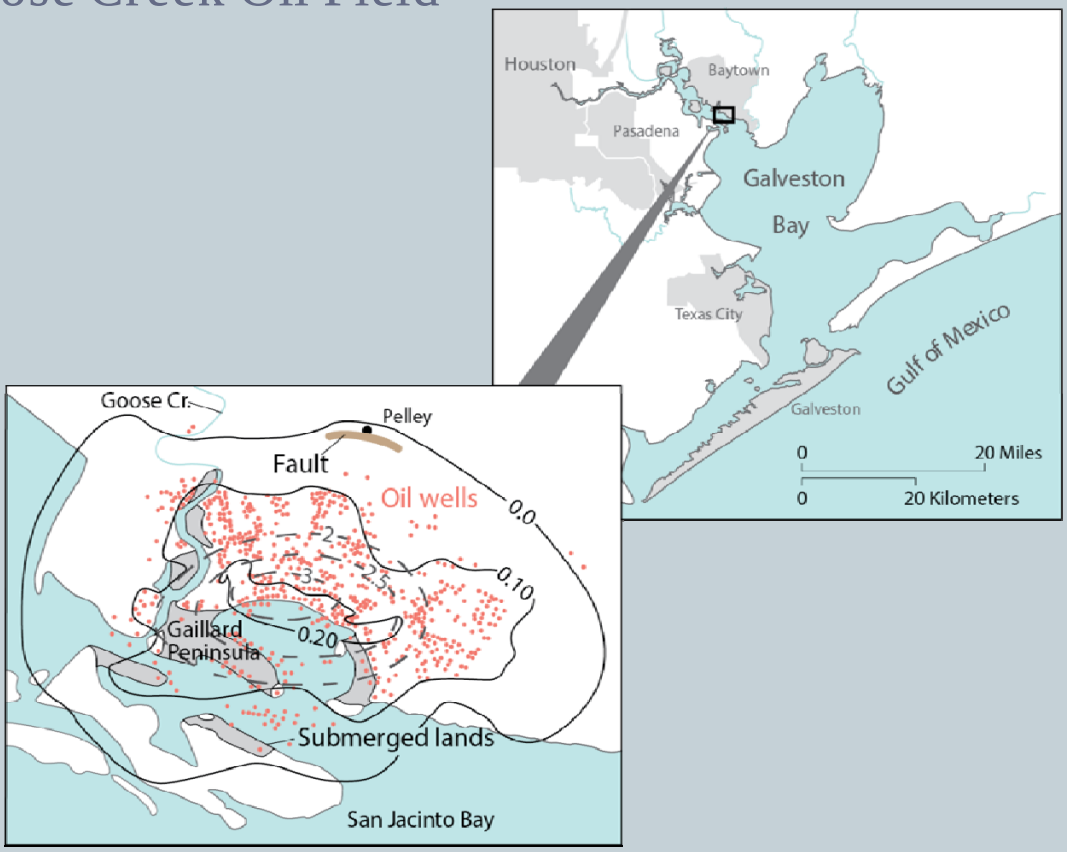
- Examples
  - Earth Fissures – Groundwater Extraction

Apache Junction Fissure, AZ

Earth Fissure, Las Vegas, NV

Occurrence

- Relation to Subsidence/Subsurface Fluid Extraction
  - Pelley Fault, Goose Creek Oil Field



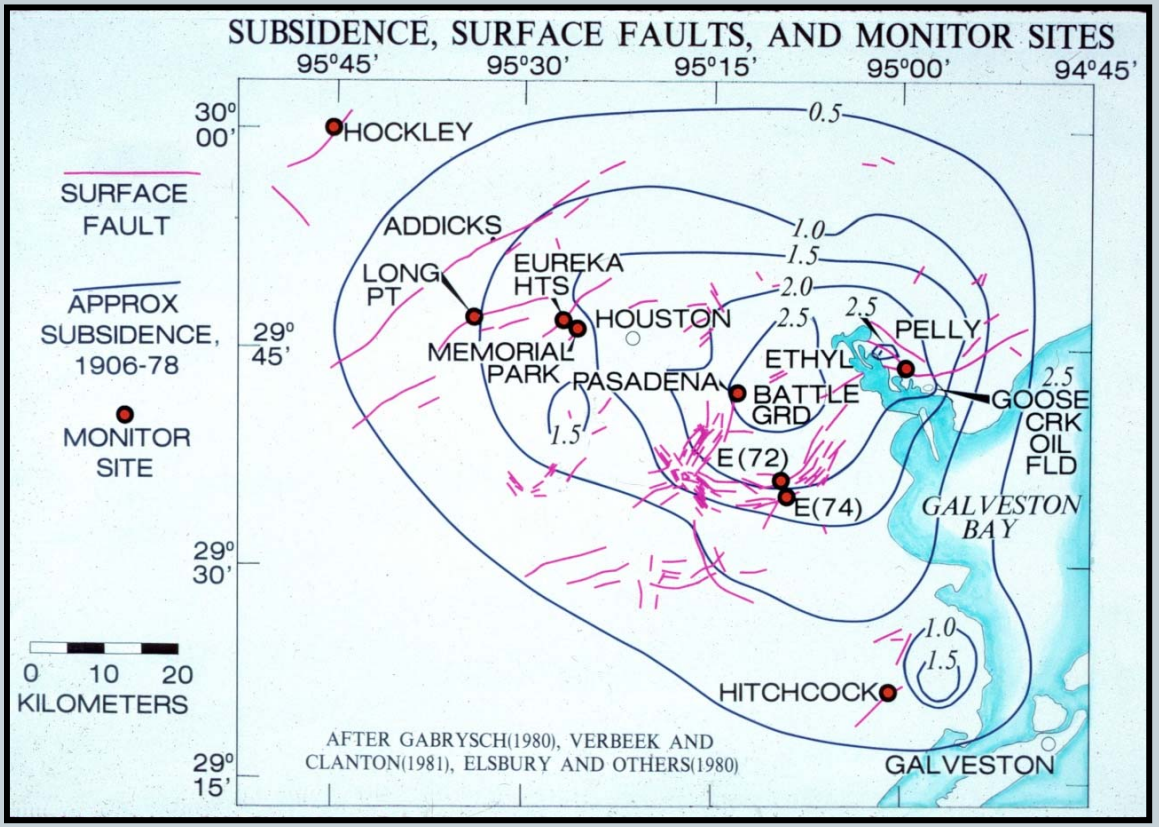
Subsidence contours: for 8-yr period (grey dash), and for 1-yr period (black) in feet, during 1918-1935.

Galloway et al. (1999)

Occurrence

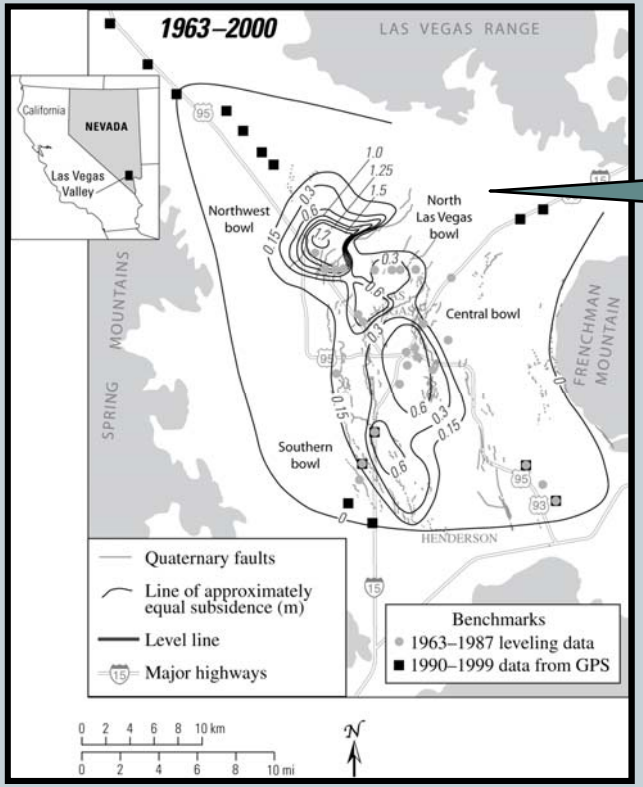
- Relation to Subsidence/Subsurface Fluid Extraction
  - Surface Faults, Houston Area, TX (Groundwater/Oil and Gas)

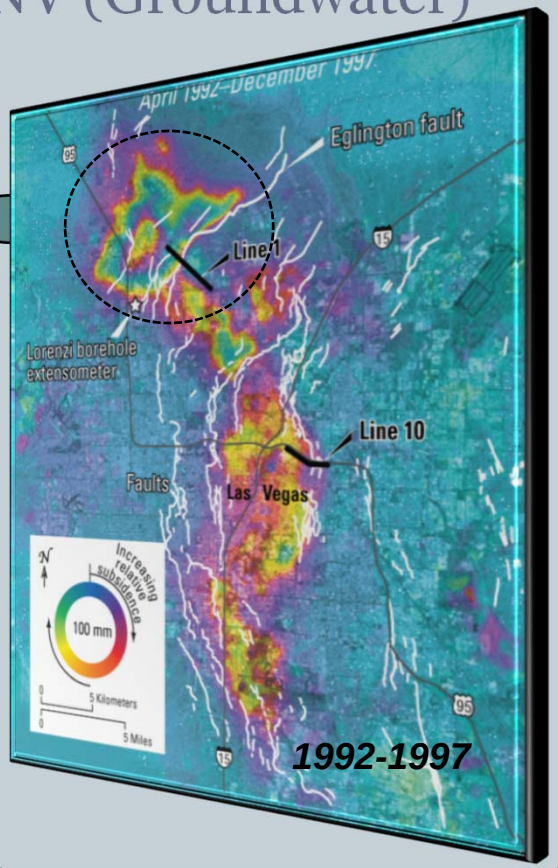
Subsidence contours:
1943-73 in meters.



Occurrence

- Relation to Subsidence/Subsurface Fluid Extraction
  - Surface Faults, Las Vegas Valley, NV (Groundwater)

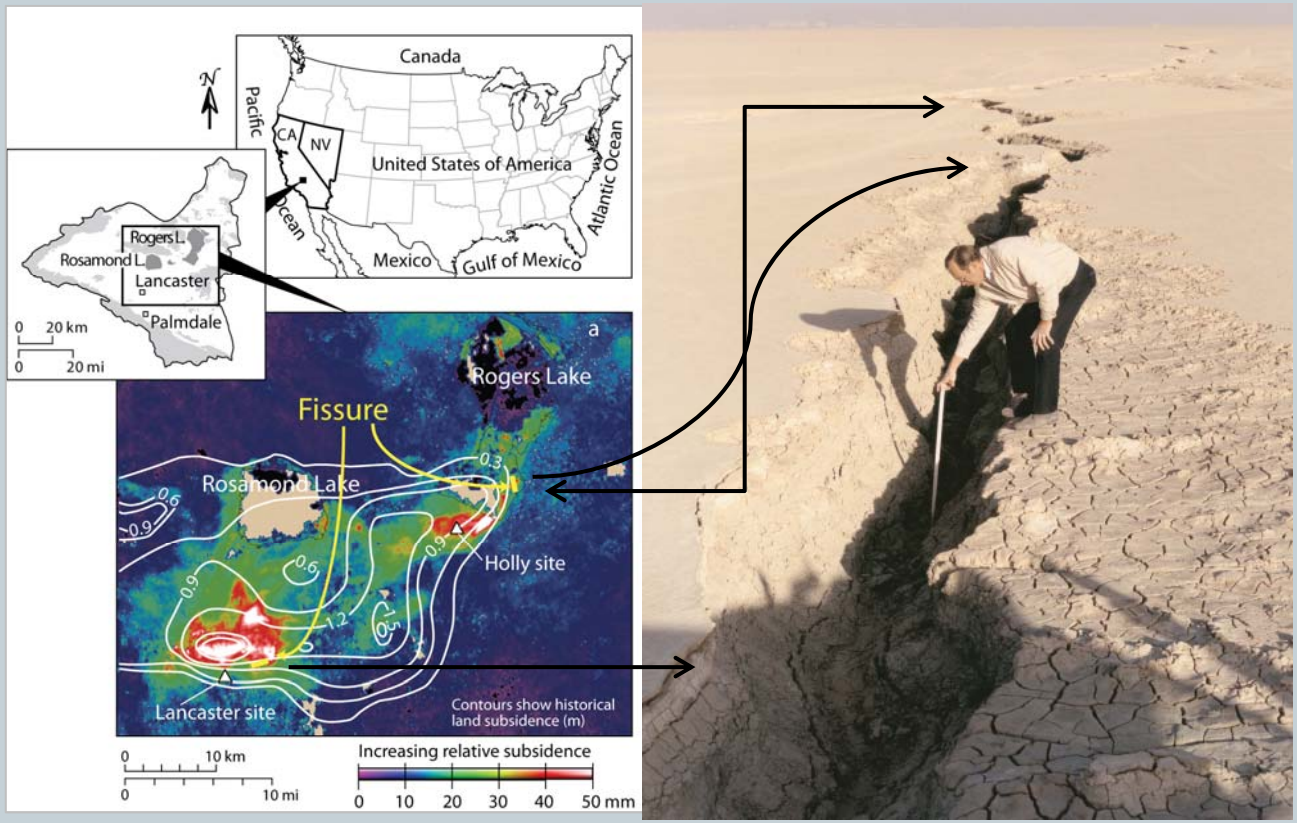




Occurrence

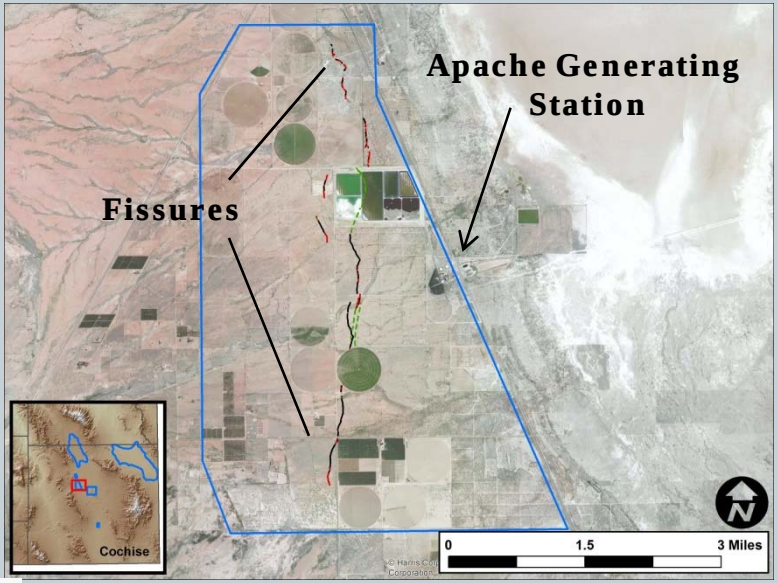
- Relation to Subsidence/Subsurface Fluid Extraction
  - Earth Fissures, Antelope Valley, CA (Groundwater)

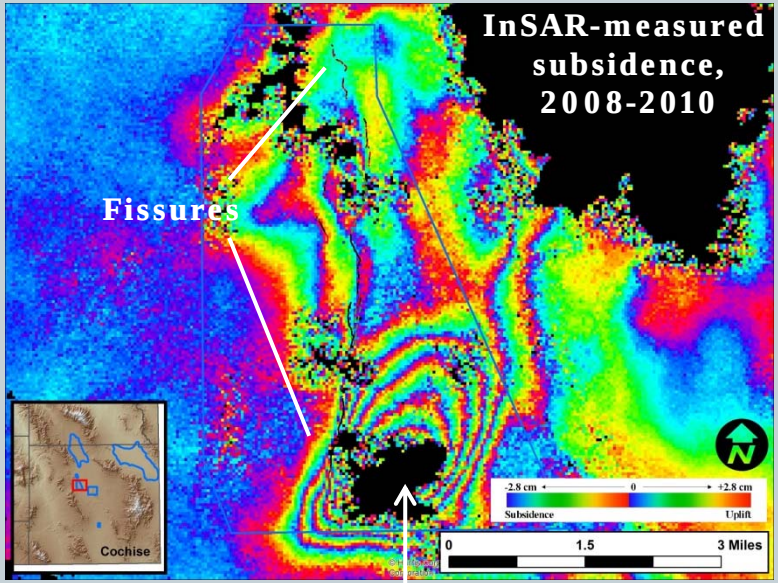
Subsidence mapped using GPS surveys (1935-1992) and InSAR (Oct. 1992-Dec. 1995). Fissure appeared in Jan 1991.



Occurrence

- Relation to Subsidence/Subsurface Fluid Extraction
  - Earth Fissures, Dragoon Rd., Cochise County, AZ (Groundwater)

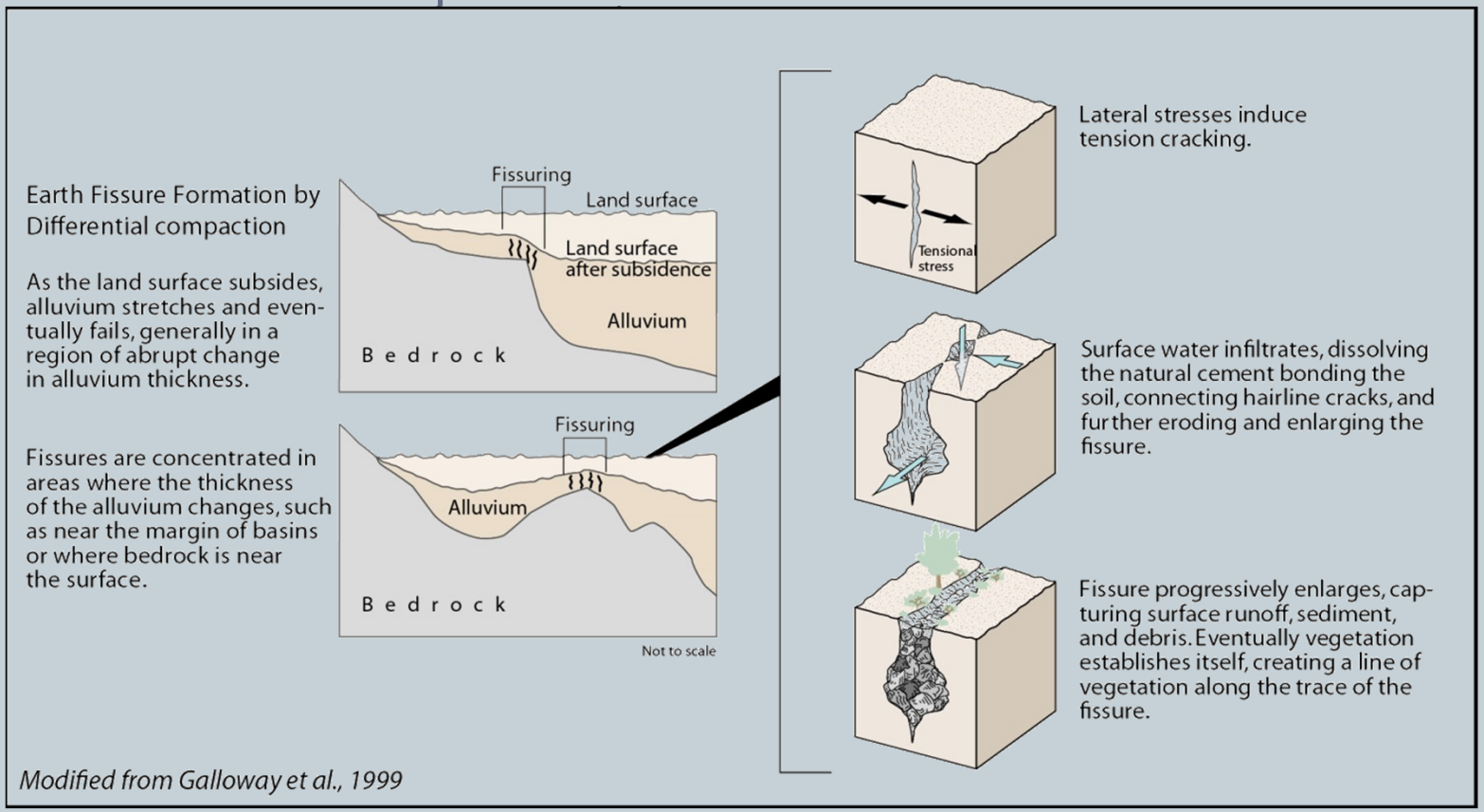




~6 cm/yr

Occurrence

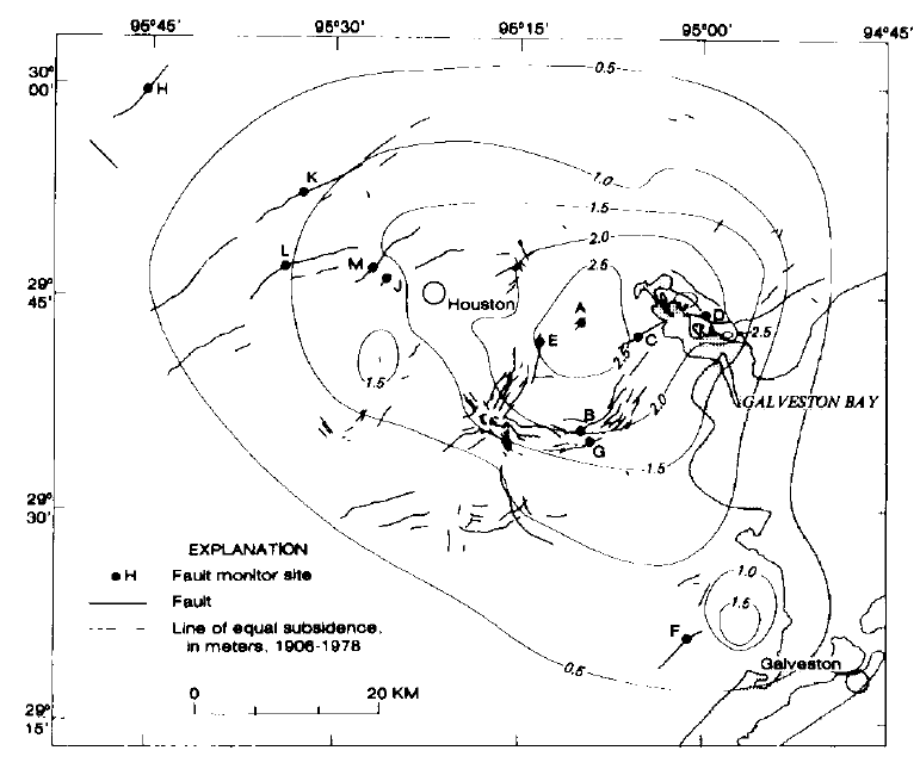
- Relation to Subsidence/Subsurface Fluid Extraction
  - Differential Compaction/Subsidence



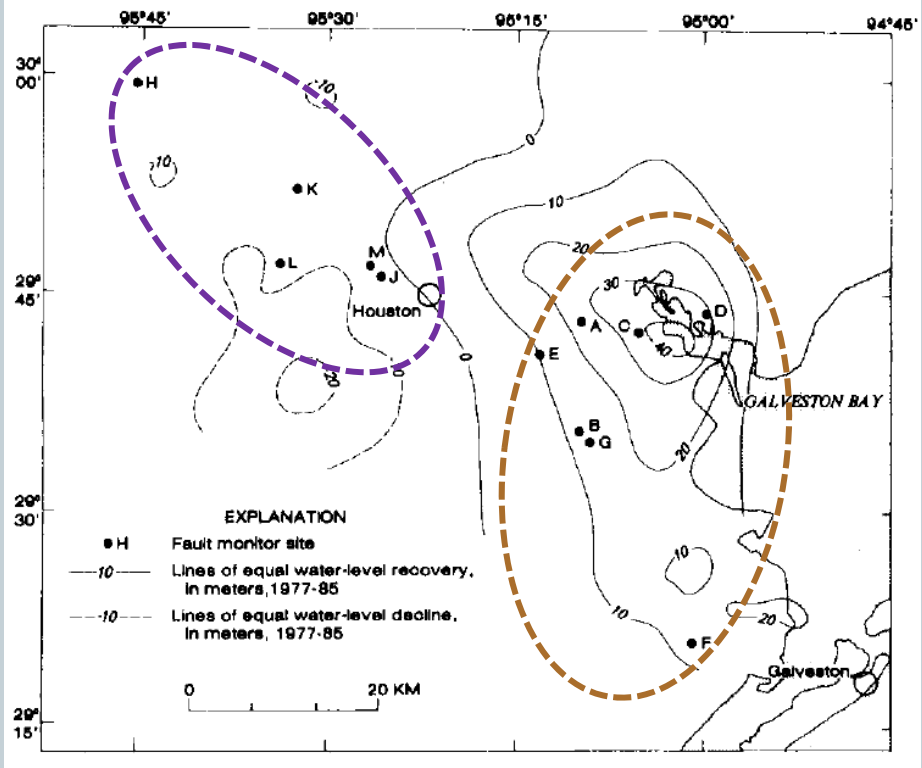
Site Measurements

- Surface Faults
  - Houston Area, TX

Subsidence 1906-78



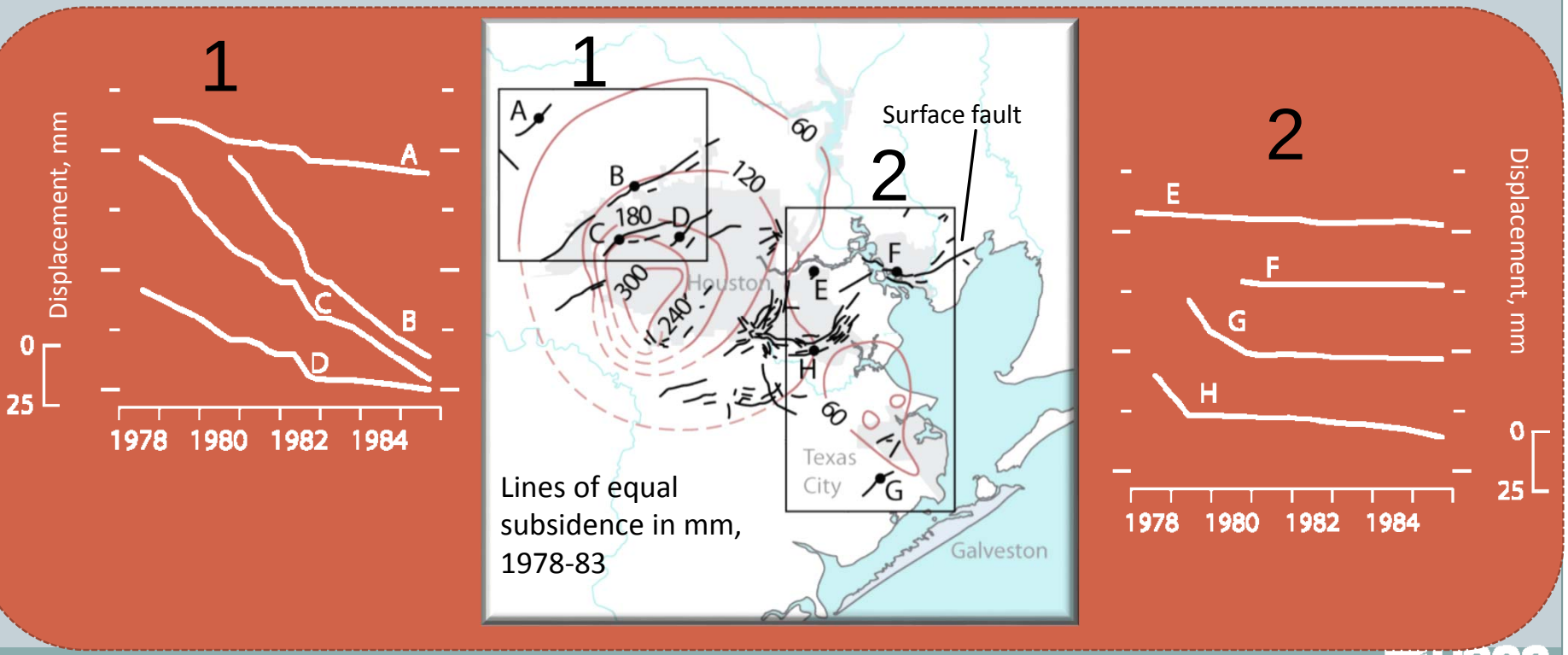
Groundwater Level Change 1977-85



Holzer and Gabrysch (1987)

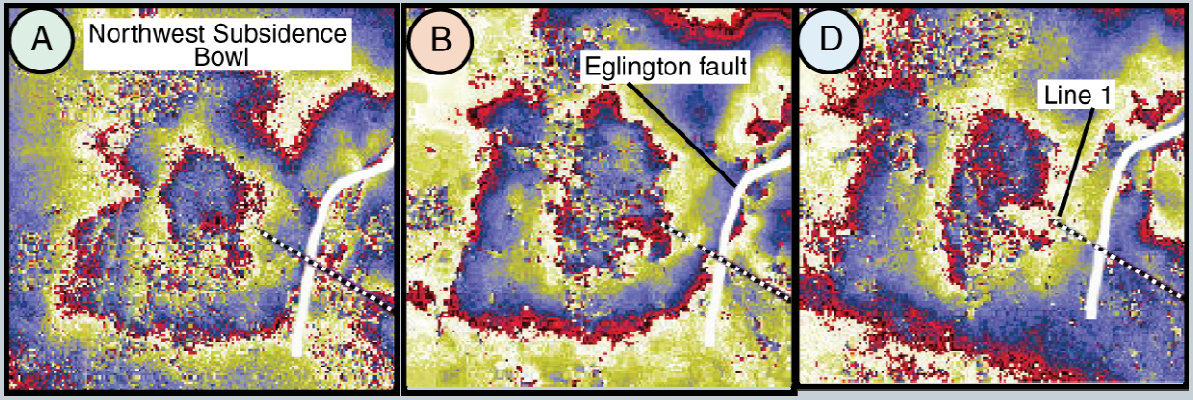
Site Measurements

- Surface Faults
  - Houston Area, TX
    - Vertical displacements on fault scarps greater in areas of groundwater-level decline and subsidence, less in areas of groundwater-level recovery and reduced subsidence

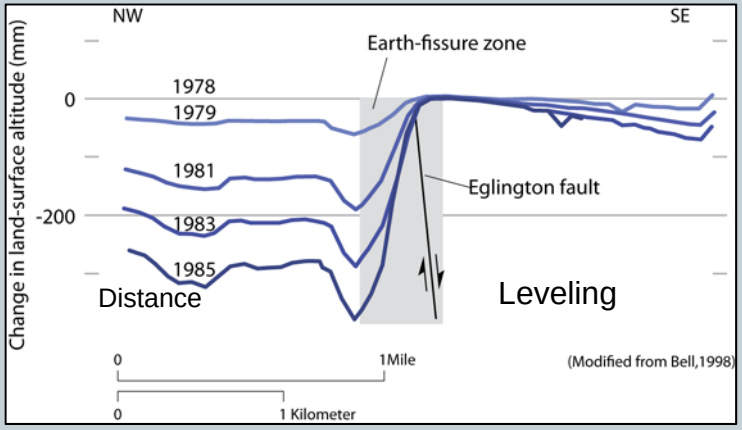


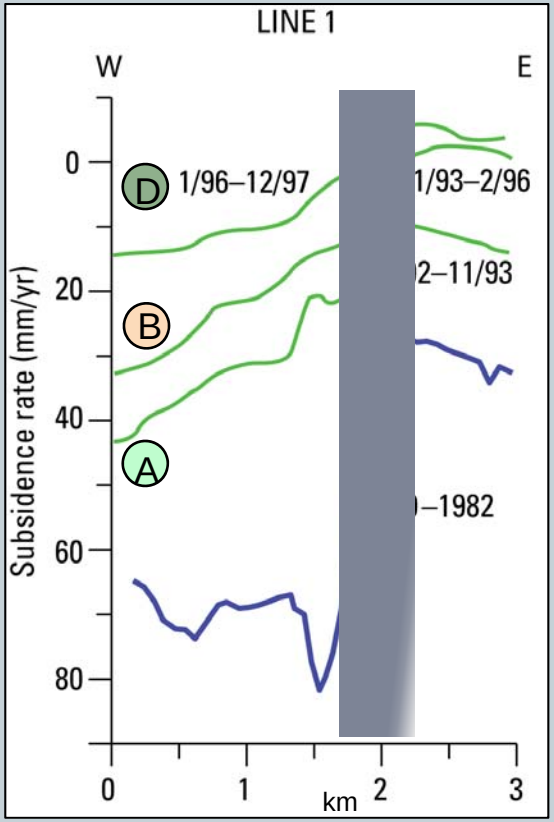
Site Measurements

- Surface Faults
  - Las Vegas Valley, NV



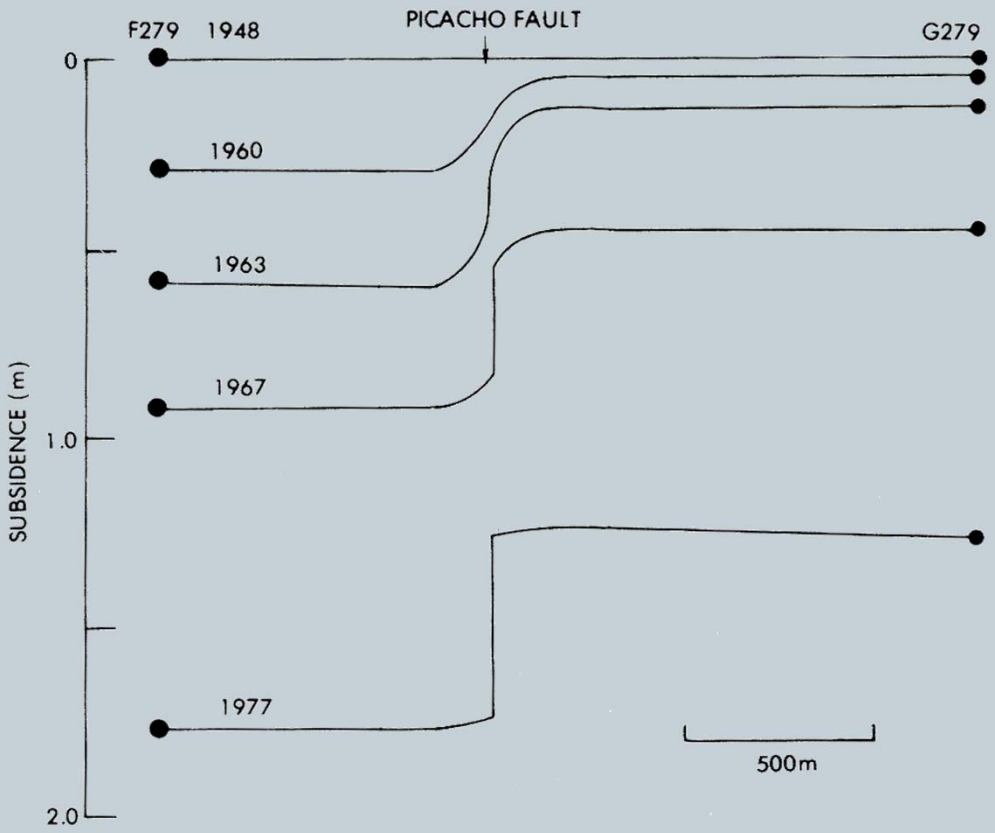
InSAR reveals a decreasing rate of differential subsidence across the Eglington fault during 1992 – 97, attributed to groundwater-level recovery.





Site Measurements

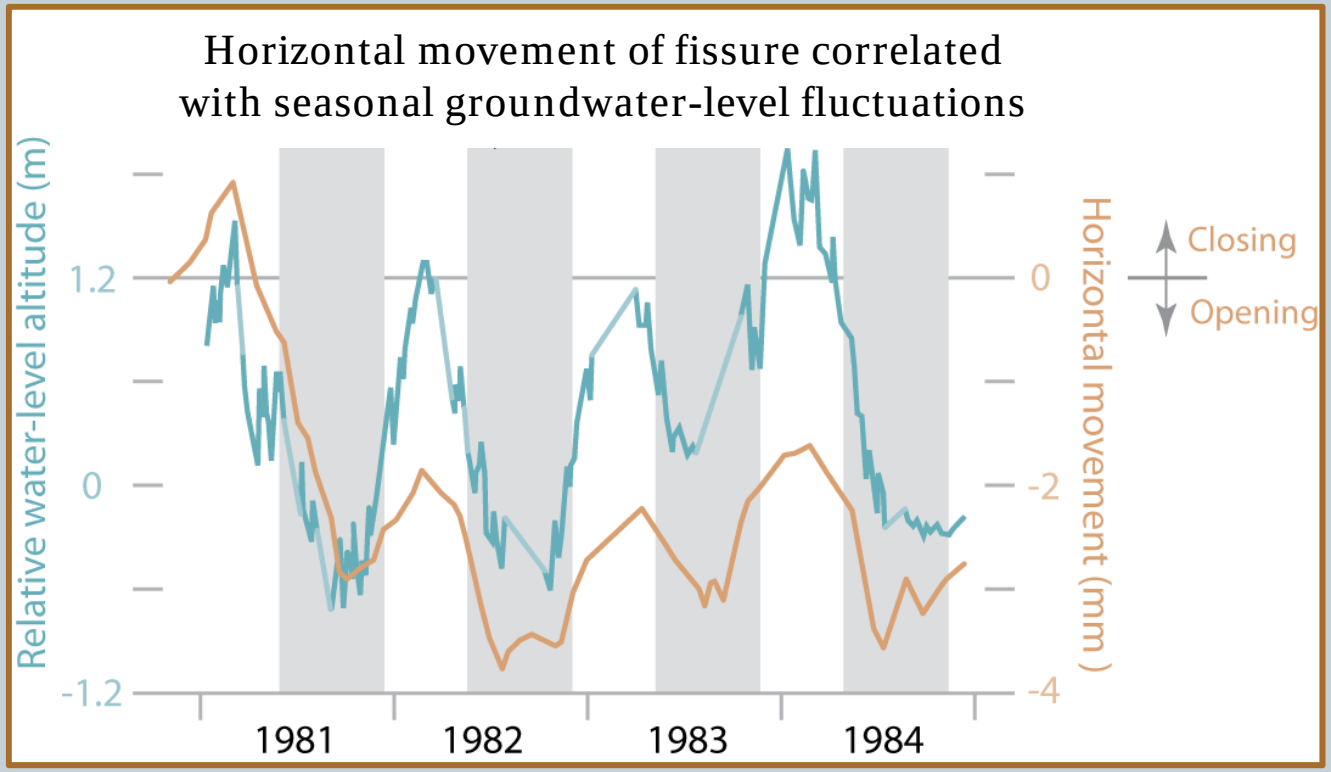
- Surface Faults
  - Picacho Fault, AZ
    - Reconstruction of deformation from leveling surveys



Holzer, Davis, and Lofgren (1978, JGR)

Site Measurements

- Earth Fissures
  - Picacho Basin, South-Central AZ



Carpenter (1993)

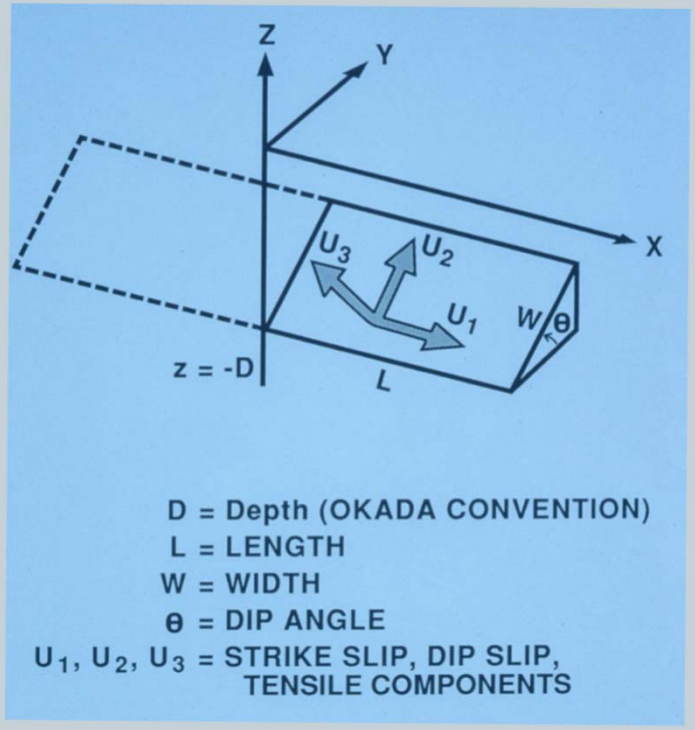
USGS

Thank you for your attention

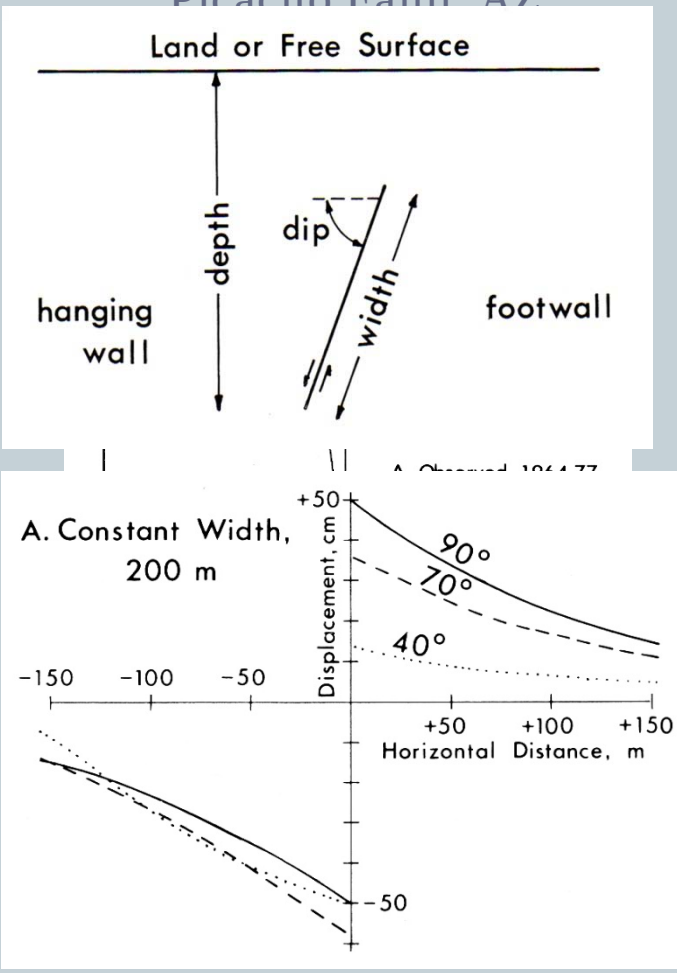
Extra Slides

Possible Mechanisms

- Movement on Surface Faults
  - Elastic Dislocation Model



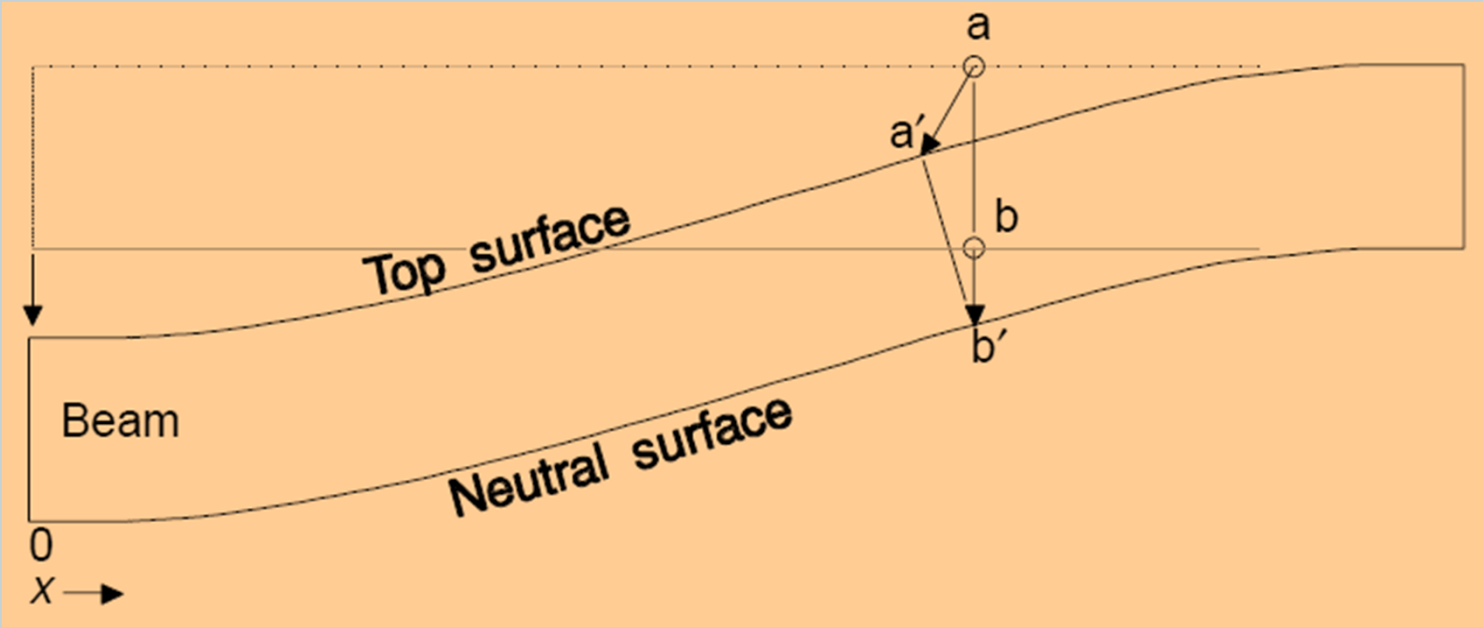
Picacho Fault, AZ



Holzer, Davis, and Lofgren (1978, JGR)

Possible Mechanisms

- Earth Fissures
  - Bending Beam Model



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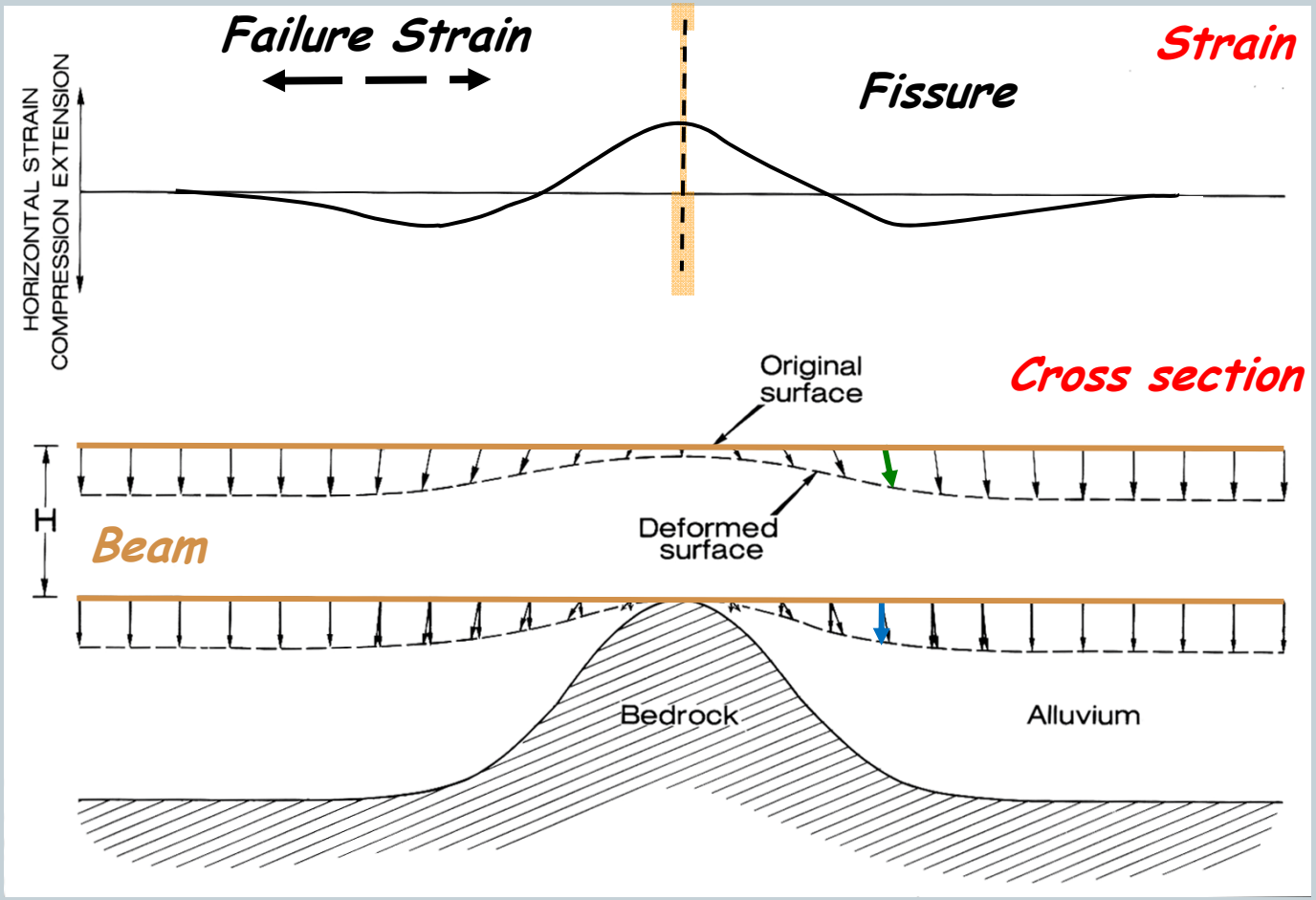

Site Measurements

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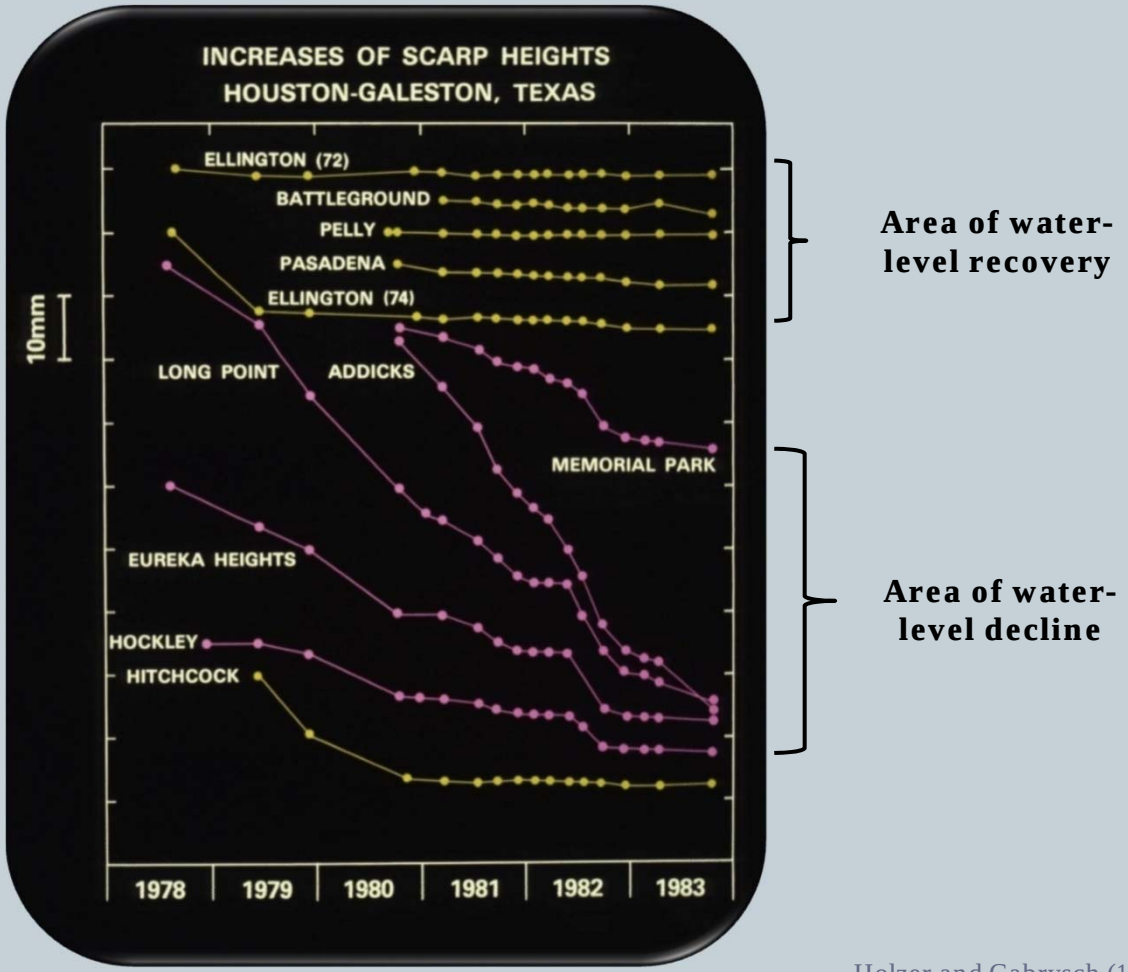
  - Houston Area, TX



Holzer and Gabrysch (1987)