U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

# NUCLEAR WASTE TECHNICAL REVIEW BOARD
# PANEL ON STRUCTURAL GEOLOGY & GEOENGINEERING

## SUBJECT: SOILS AND GEOMORPHIC STUDIES - PART I


**PRESENTER:** DR. LESLIE D. McFADDEN

**PRESENTER'S TITLE AND ORGANIZATION:** ASSOCIATE PROFESSOR
UNIVERSITY OF NEW MEXICO

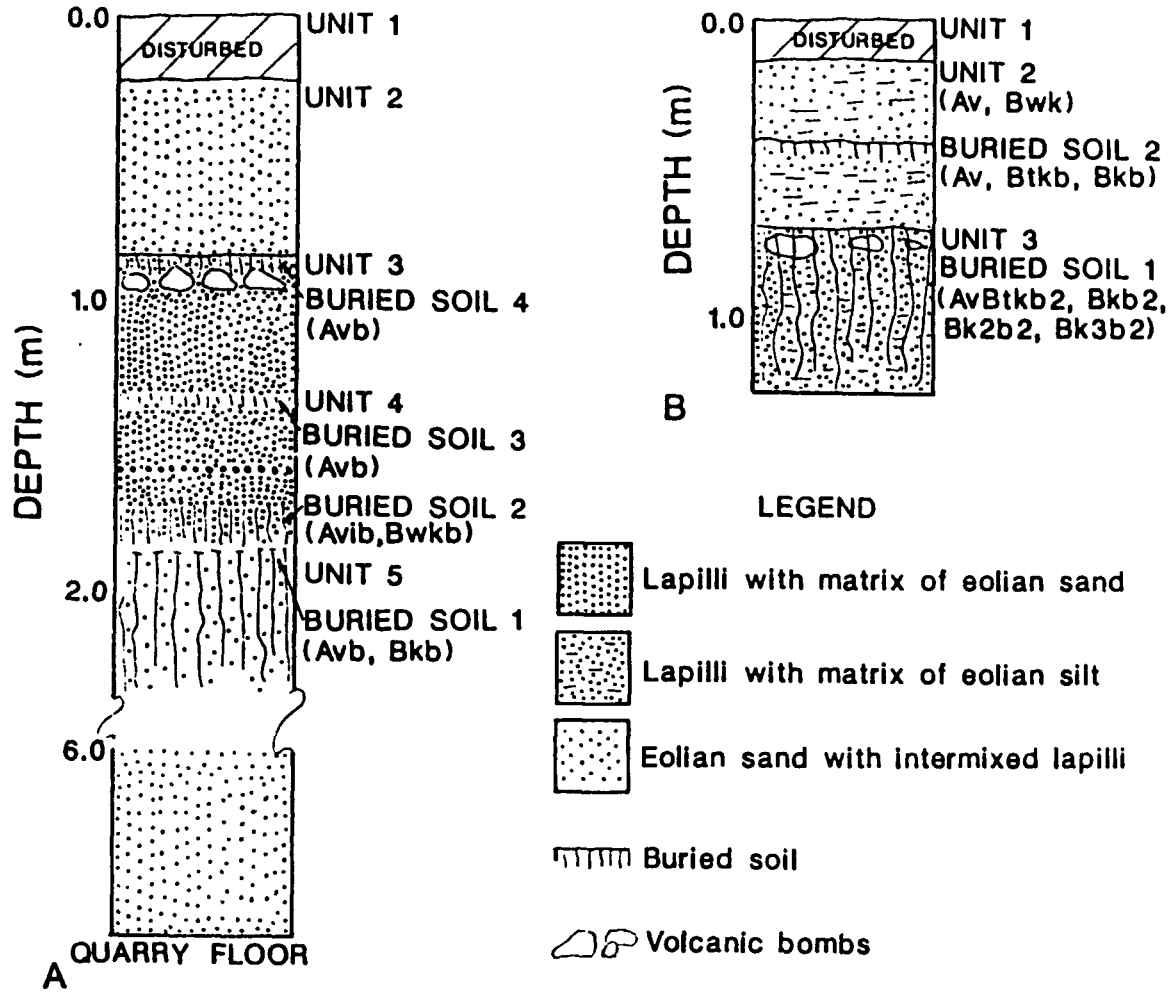
**PRESENTER'S TELEPHONE NUMBER:** (505) 277-6528


ALEXIS PARK HOTEL
SEPTEMBER 14 - 16, 1992

# Photograph of Lathrop Wells Cone, Nevada

# Photograph of quarry and exposures of volcanic deposits, Lathrop Wells cinder cone

# Measured Stratigraphic Sections




**A: Lathrop Wells cone, Crater Flat volcanic field, Nevada B: Black Tank cone, Cima volcanic field, California. Diagonal lines = deposits distributed by human activity; vertical wavy lines = soil development; symbols in parentheses = soil-horizon nomenclature.**

SOILGEOM3.125.NWTRB/9-14/16-92

# Soil and Geomorphic Evidence for Late Quaternary Polycyclic Volcanism at Lathrop Wells Cone: Principle Areas of Concern

- Heterolithic lapilli-rich, quartzo-feldspathic deposits exposed in the Lathrop Wells Quarry: pedogenically modified primary fall-out deposits, or sediments emplaced via mass movement processes

- Age estimates for soils and geomorphic features at Lathrop Wells: Evidence for age estimate and basis for calibration, correlation

# Soil development on Volcanic Flows in Arid Regions: Overview of Soil-Geomorphic Studies in the Cima Volcanic Field, California

- Soil development on scoria deposits: Ongoing studies at Lathrop Wells and Cima
  - Characteristic field properties, horizons
  - Textural, chemical, and mineralogical properties
  - Complex pedogenic and nonpedogenic features
- Lathrop Wells soils and particle-size characteristics: A critical analysis based on examination of pedologic and sedimentologic data
- Age estimates from soil data
- Future studies

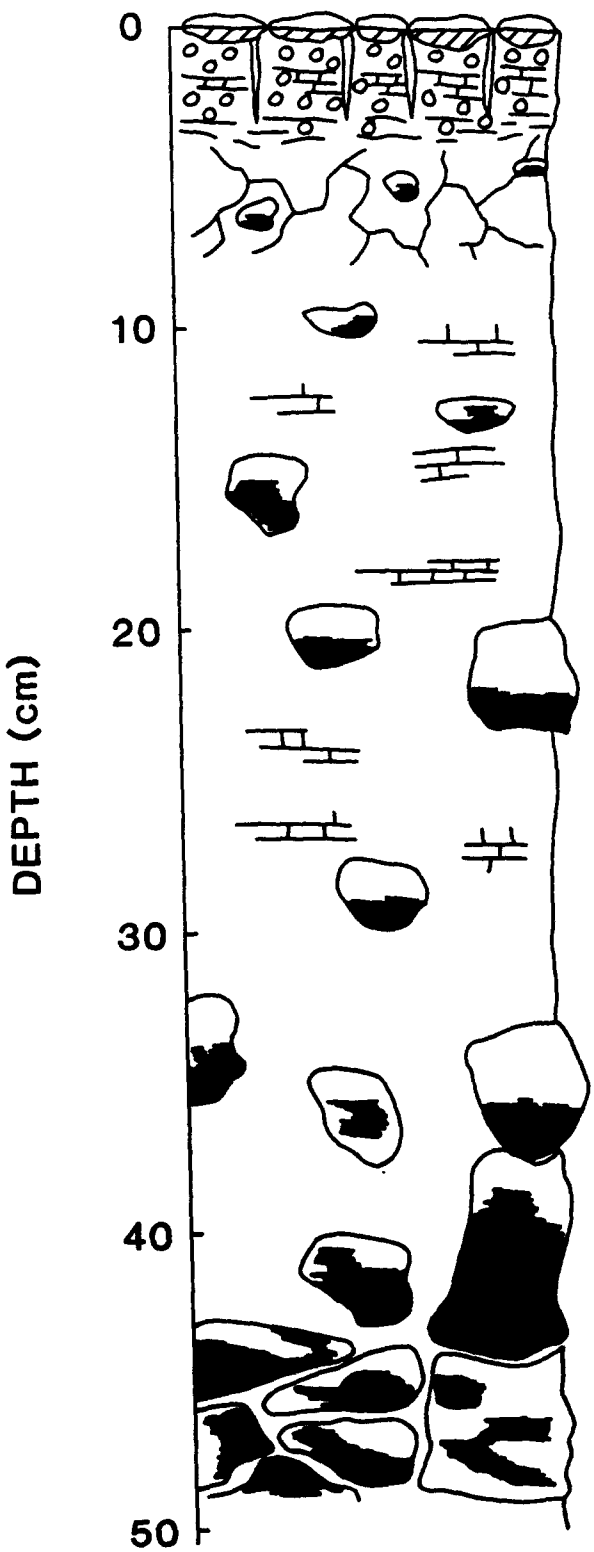
# Aerial photograph of the Cima volcanic field, Mojave Desert, California

SOILGEOM6.125.NWTRB/9-14/16-92

# Photograph of weakly developed Phase 1 soil, Cima volcanic field

# Photograph of well developed Phase 2 soil on volcanic flow, Cima volcanic field

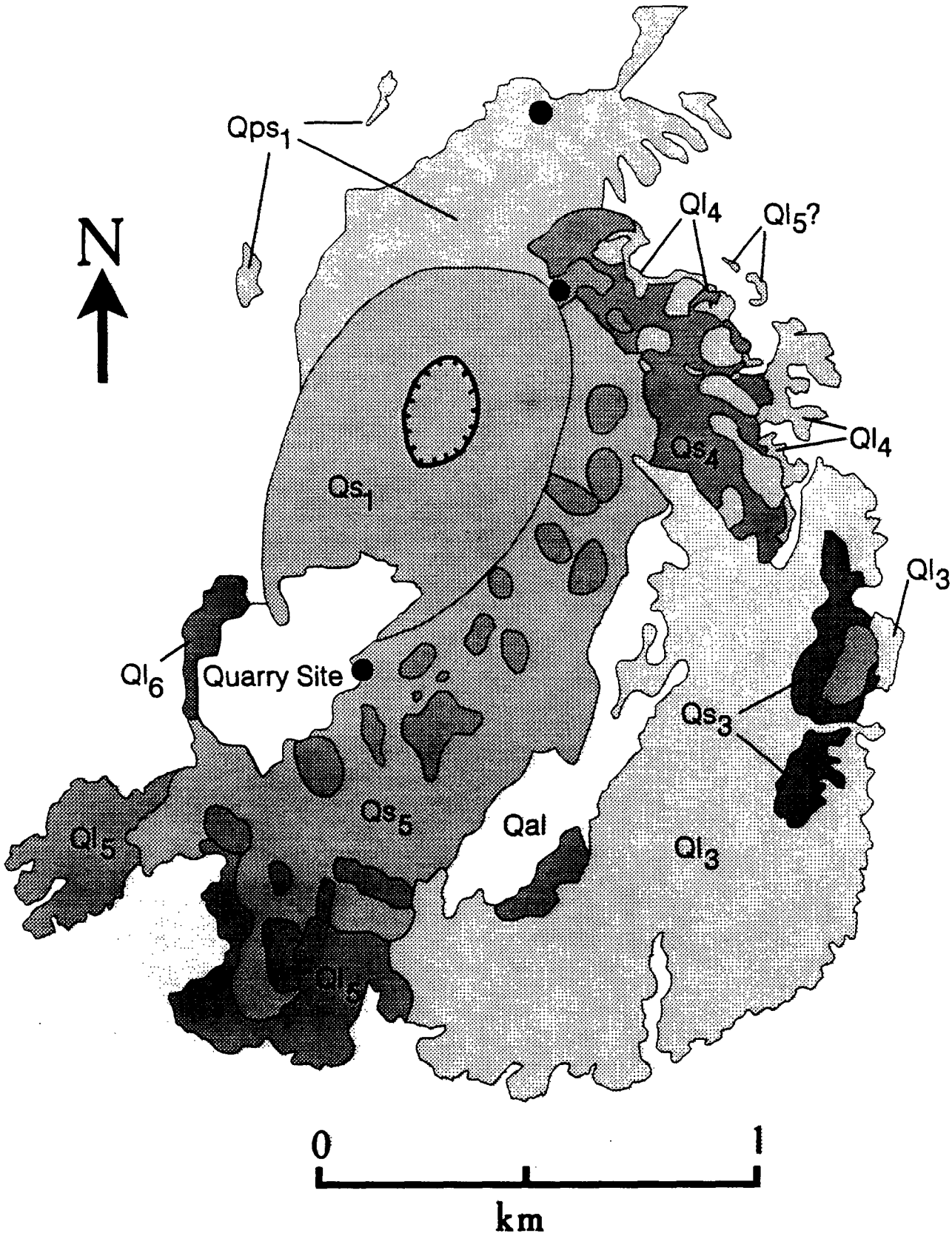
# Photograph of vesicular A (Av) horizon, Cima volcanic field



# Photograph of soil developed in tephra of Black Tank cone (A cone), Cima volcanic field

SOILGEOM11.125.NWTRB/9-14/16-92

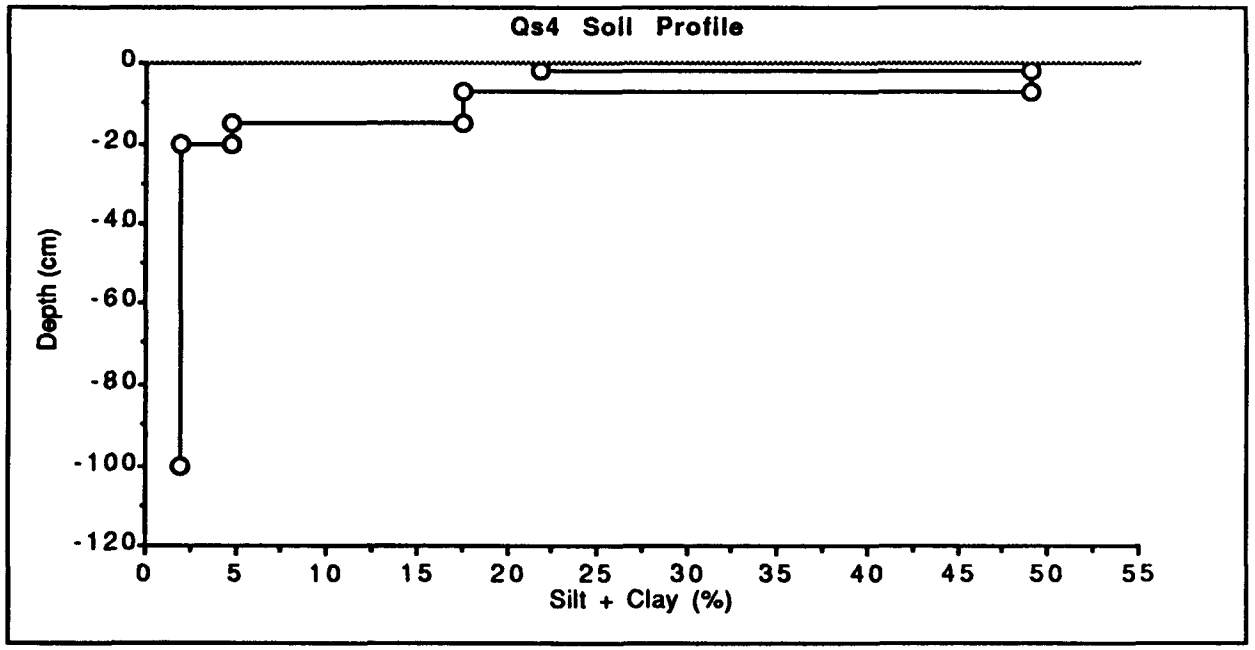
# Lathrop Wells Volcanic Center



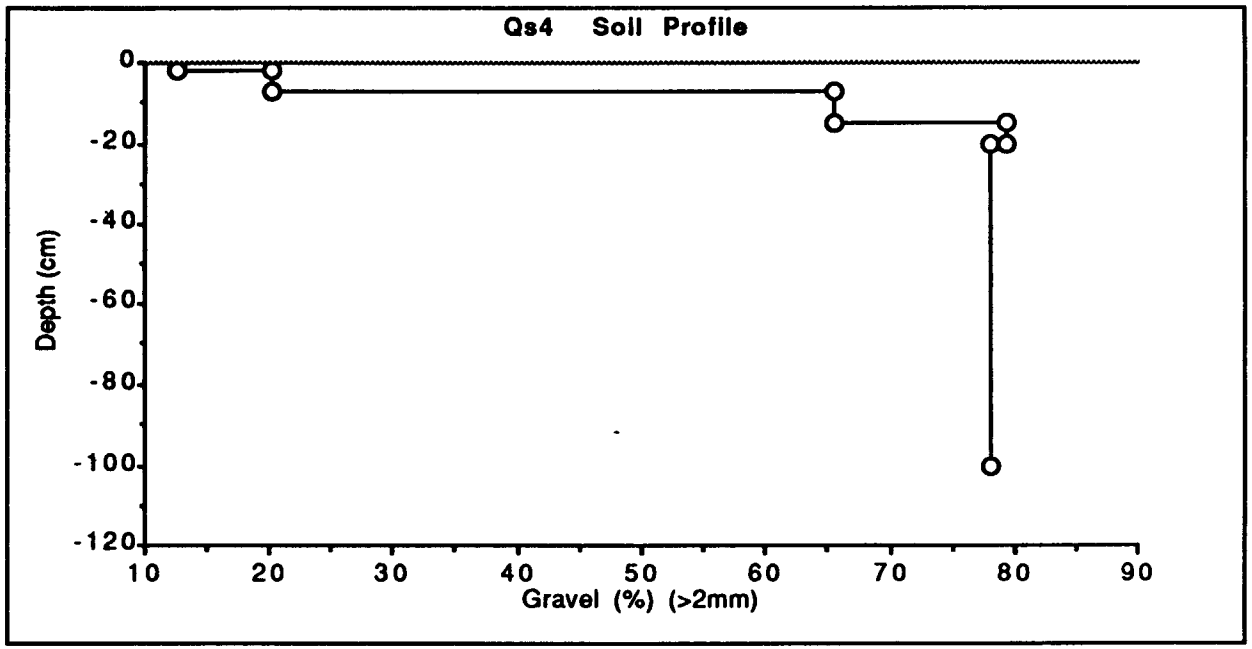
# Photograph of soil formed in pyroclastic surge deposit, Lathrop Wells cone

| Profile Sequence Depth (cm) | | Typical Field Properties |
|---|---|---|
| Scoria Pavement | | |
| Avk | 0 - 5 | Very pale brown sandy clay loam; strongly effervescent; many fine & strong angular blocky structure; medium vesicular pores; low gravel % |
| ABvk or Bwk | 5 - 20 | Gravelly very pale brown sandy loam; effervescent; few to no vesicular pores; medium subangular blocky; moderate gravel content |
| Bkys1 | 20 - 40 | Very gravelly very pale brown sandy loam; effervescent, carbonate coatings on bases of scoria particles & loamy coatings on tops & sides; interstitial pores |
| Bkys2 | 40 - > 100 | Scoria; carbonate and salt coatings on bases & oxidized on tops of scoria clasts single grain, loose loamy sand in voids |

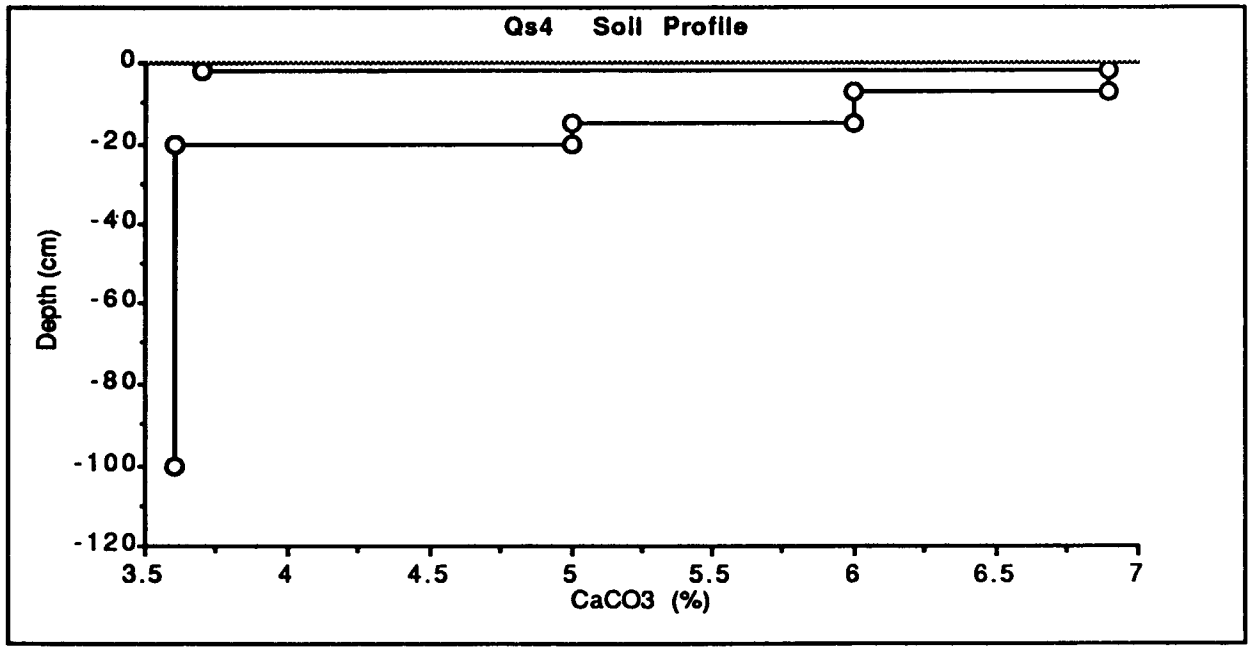
# Qs4 Soil Profile: Silt + Clay (%)



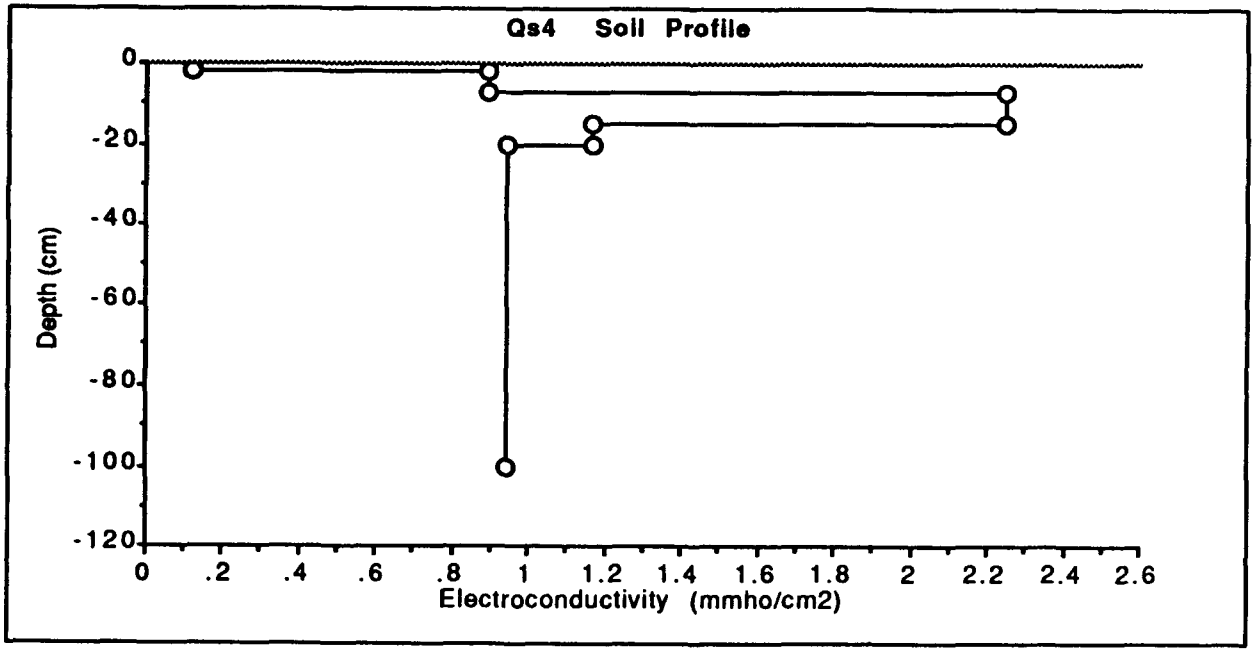
# Qs4 Soil Profile: Gravel (%) (>2 mm)



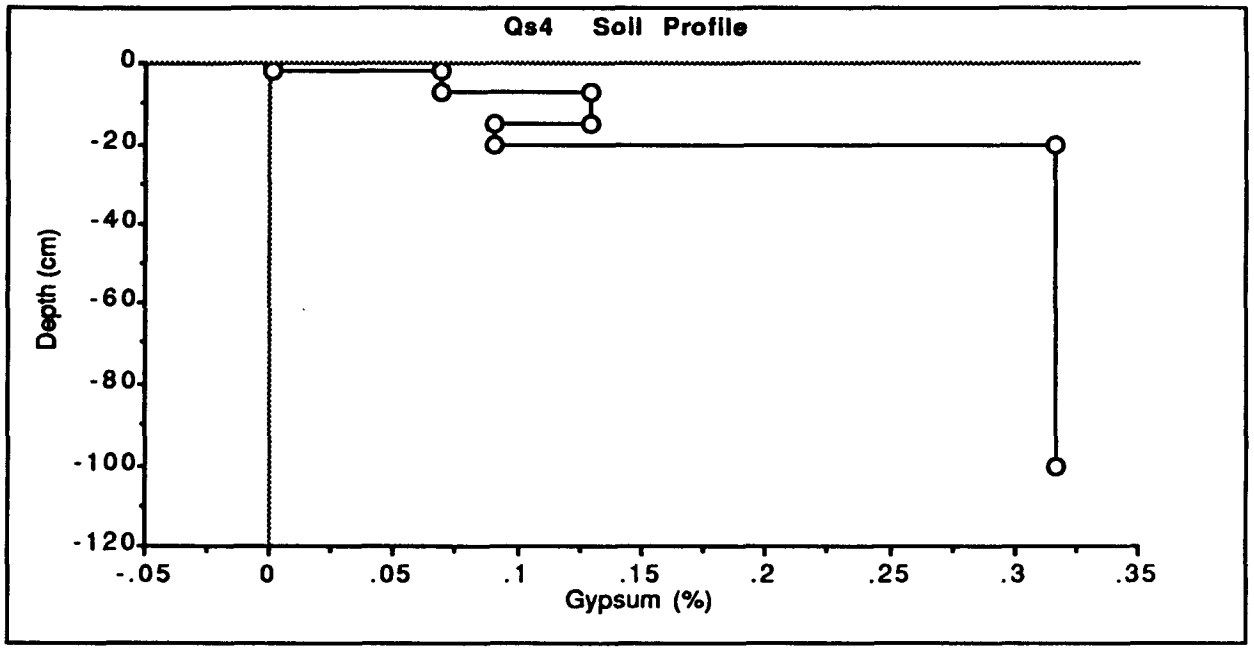
# Qs4 Soil Profile: CaCO3 (%)



# Qs4 Soil Profile: Electroconductivity (mmho/cm2)



# Qs4 Soil Profile: Gypsum (%)



# Primary Processes Influencing Soil Development in Scoria

- Entrapment of calcareous, salt-bearing eolian dust
- Infiltrating soil water redistributes eolian materials by entrainment of solid particles, colloidal and solution transport to form the vesicular A and subjacent B horizon matrix.
- Soil development directly associated with scoria framework grains includes (1) limited chemical alteration and formation of secondary Fe oxides and silica and (2) preferential accumulation of pedogenic calcium carbonate, salts, silt and clay coatings on the grain surface
- Increasing clay content favors dilatant, cumulic soil development above the framework-supported scoria parent material

# Photograph showing krotovina feature caused by bioturbation in pyroclastic deposit, Lathrop Wells cone

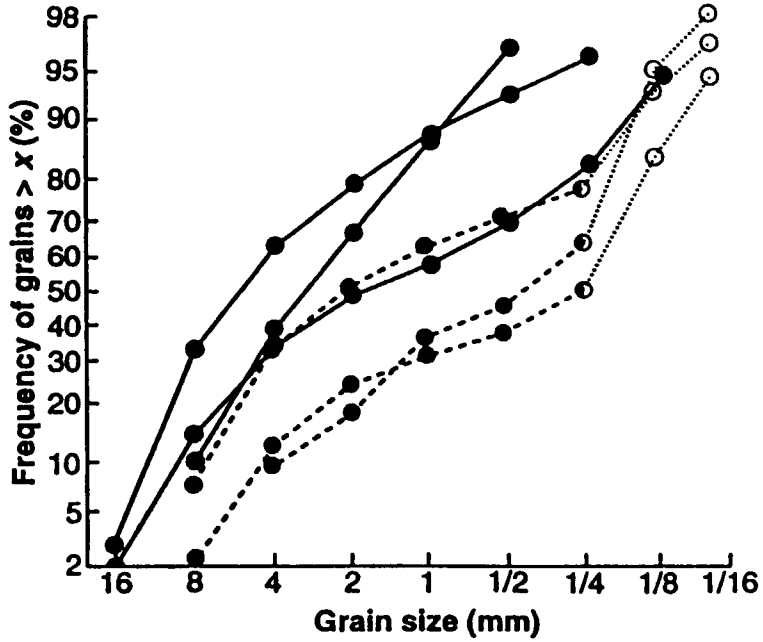
SOILGEOM21.125.NWTRB/9-14/16-92

# Photograph of dissected scoria, Cima volcanic field

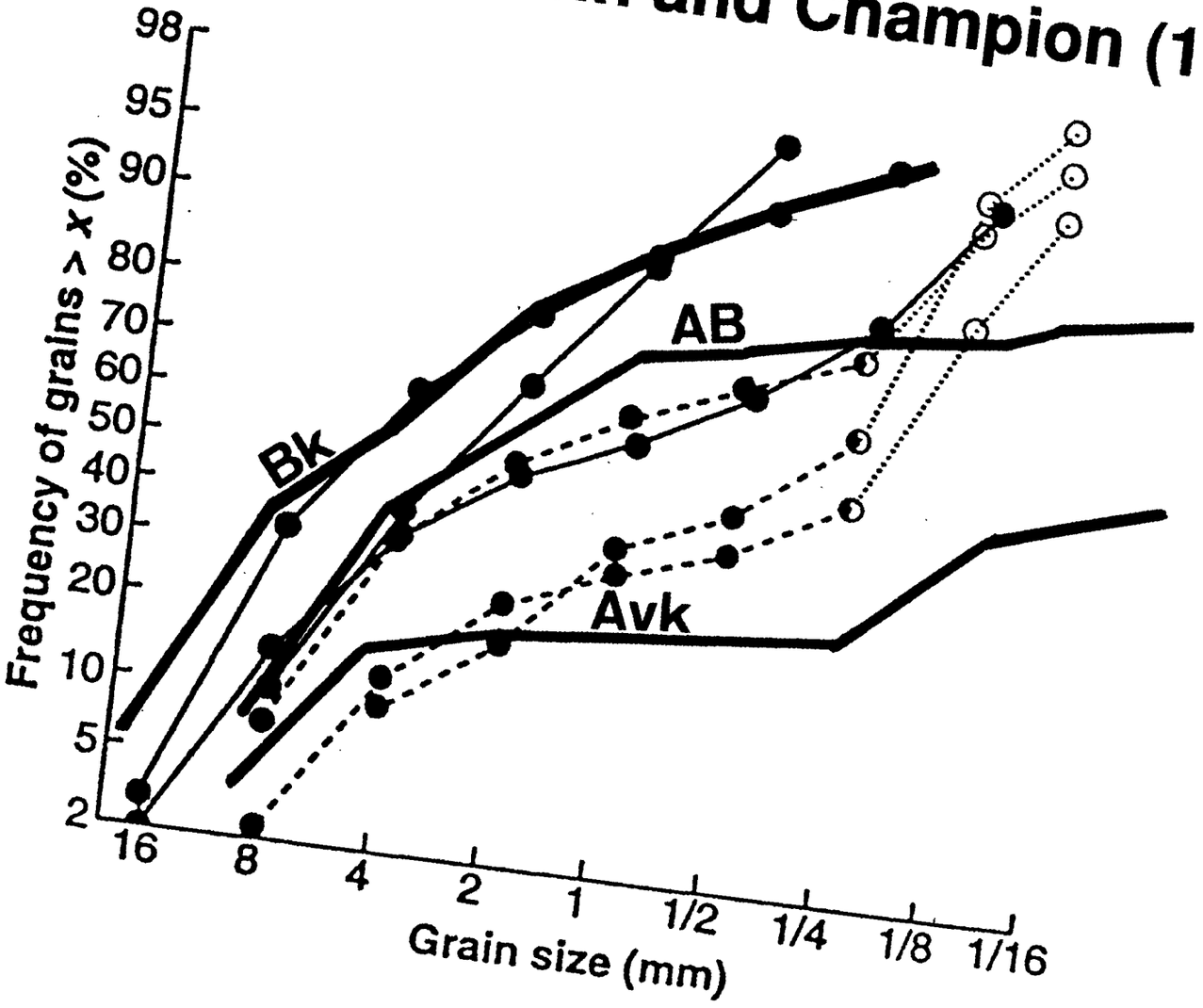
# Photograph of non-pedogenic silty loam accumulation in scoria deposit, Cima volcanic field

# Photograph of non-pedogenic silty loam accumulation (close-up) in scoria deposit, Cima volcanic field

# Turrin and Champion (1992)



# Qs4 Soil Horizons (Heavy Solid Line) and Data from Turrin and Champion (1992)




SOILGEOM.125.NWTRB/9-14/16-92

# Comparison of Lathrop Wells Quarry Deposits and Soil Development in $Qs_4$ Scoria: Conclusions

(1) Similarity of particle size data indicates that such data do not (a) eliminate a pedogenic origin for the basal parts of units exposed in Lathrop Wells Quarry and (b) certainly do not uniquely identify a "cone apron" depositional environment.

(2) Pedogenic origin of the Lathrop Wells Quarry units is shown by:
- Presence of systematically spatially oriented, pedogenically accumulated coatings on scoria framework grains
- Depth functions of <2 mm materials
- Presence of "vesicular A" horizons above Bwk or Bk horizons

# Comparison of Lathrop Wells Quarry Deposits and Soil Development in $Qs_4$ Scoria: Conclusions

(CONTINUED)

(3) Pedogenic origin and the observed large "QF" component

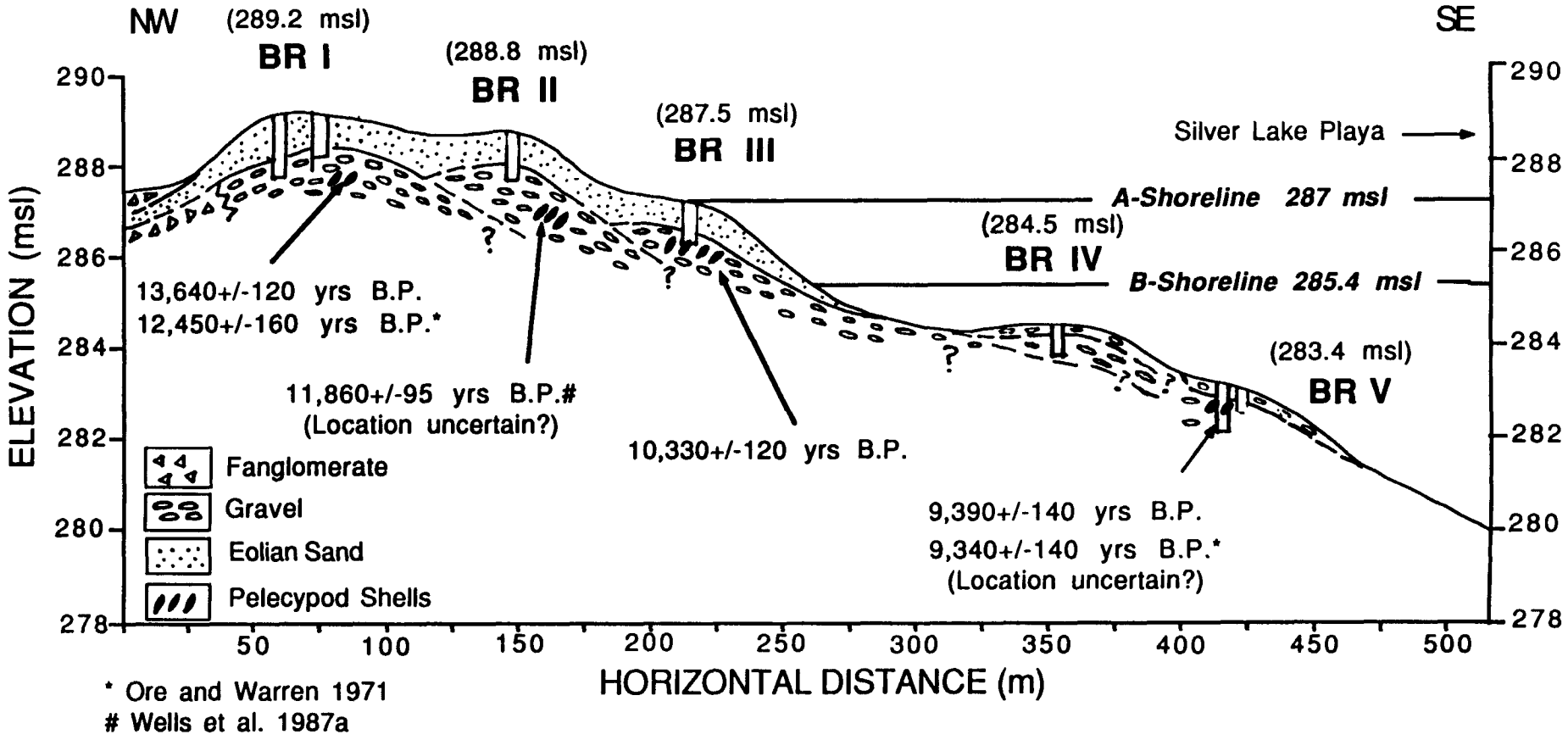
- Cumulic, dilatant soil development enables continued accumulation of fine-grain matrix that can ultimately greatly exceed depositional primary porosity
- Stratigraphic character of deposits (decimeters thick, bounded by buried Av horizons) precludes accumulation of translocated fines over large depth (ie > 2 meters) but instead favors accumulation of matrix in "basal parts" of units
- Appropriate consideration of volume-weight %-bulk density relations and particle size data ?

# Classification of Quaternary Dating Methods: Soil and Weathering Data

(After Coleman, Pierce, and Birkeland, 1987)

| Method | Result | |
|---|---|---|
| | Most Common | Least Common |
| Soil-profile Development | Relative Age | Calibrated Age |
| Rock and Mineral Weathering | Relative Age | Calibrated Age |
| Soil Chemistry | Relative Age<br>Calibrated Age | Numerical Age |

# Stratigraphic Cross Section
# El Capitan Beach Ridge Complex




* Ore and Warren 1971
\# Wells et al. 1987a

SOILGEOM.125.NWTRB/9-14/16-92

# Photograph of soil in sand, beach ridge gravels of latest Pleistocene and Holocene age, Silver Lake Playa, California

# Photograph of soil in Holocene fan deposit of the Soda Mountains, Silver Lake Playa area, California

SOILGEOM32.125.NWTRB/9-14/16-92

# Photograph of a well developed Pleistocene soil in fan deposits, Cima volcanic field, California

# Future Studies of Soils in Scoria

- Bulk chemistry
- Soil mineralogy
- Soil micromorphology
- Isotopic analyses
- Radiocarbon dating of carbonate
- Evaluation of larger data set (ie, more soils)