

# **Geological Evidence of Past Climatic and Hydrologic Regimes of the Great Basin**

## **The Alluvial Fan Record from the Eastern Mojave Desert**

**Dr. Eric McDonald**





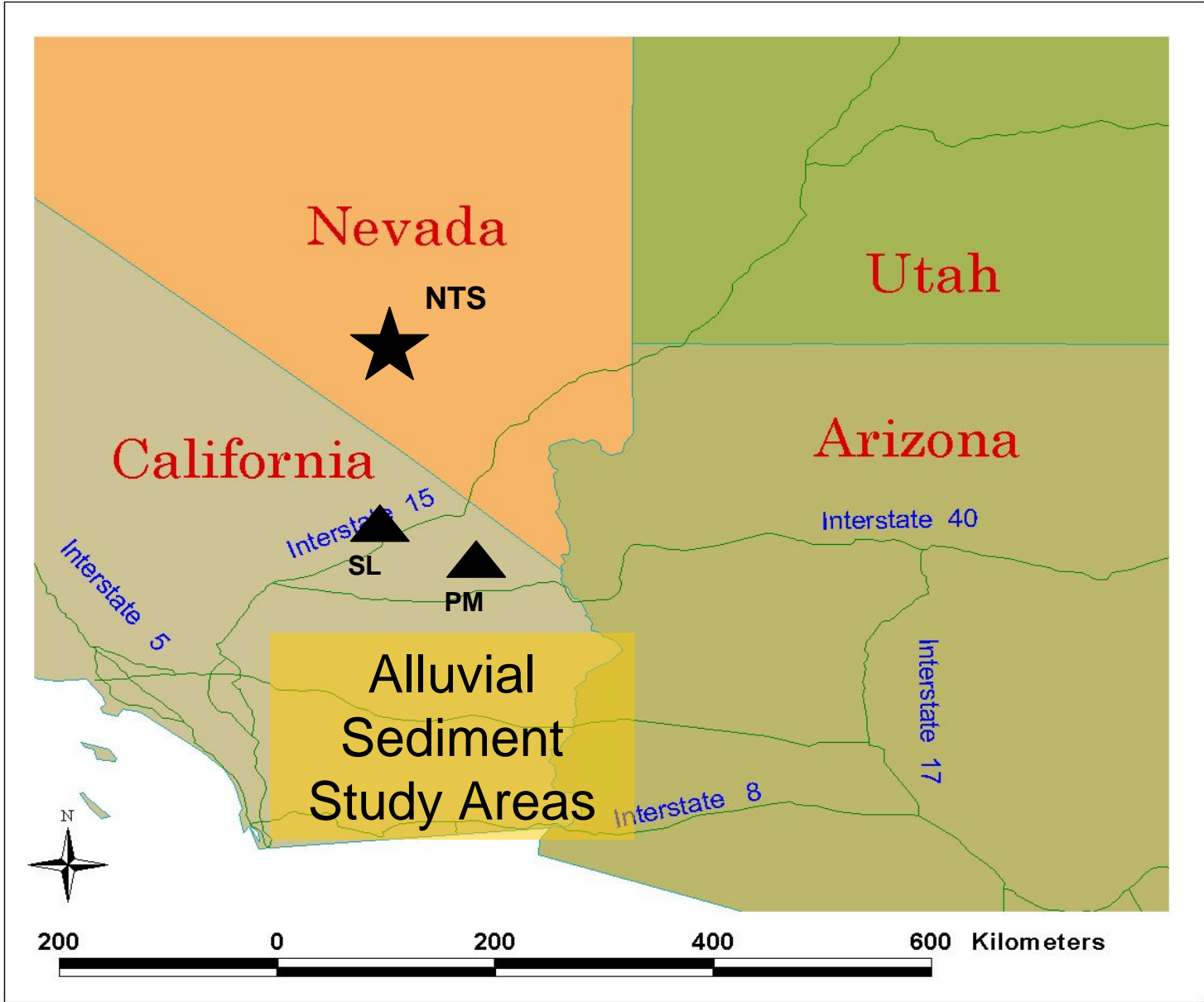
Examples of  
Alluvial  
Fans

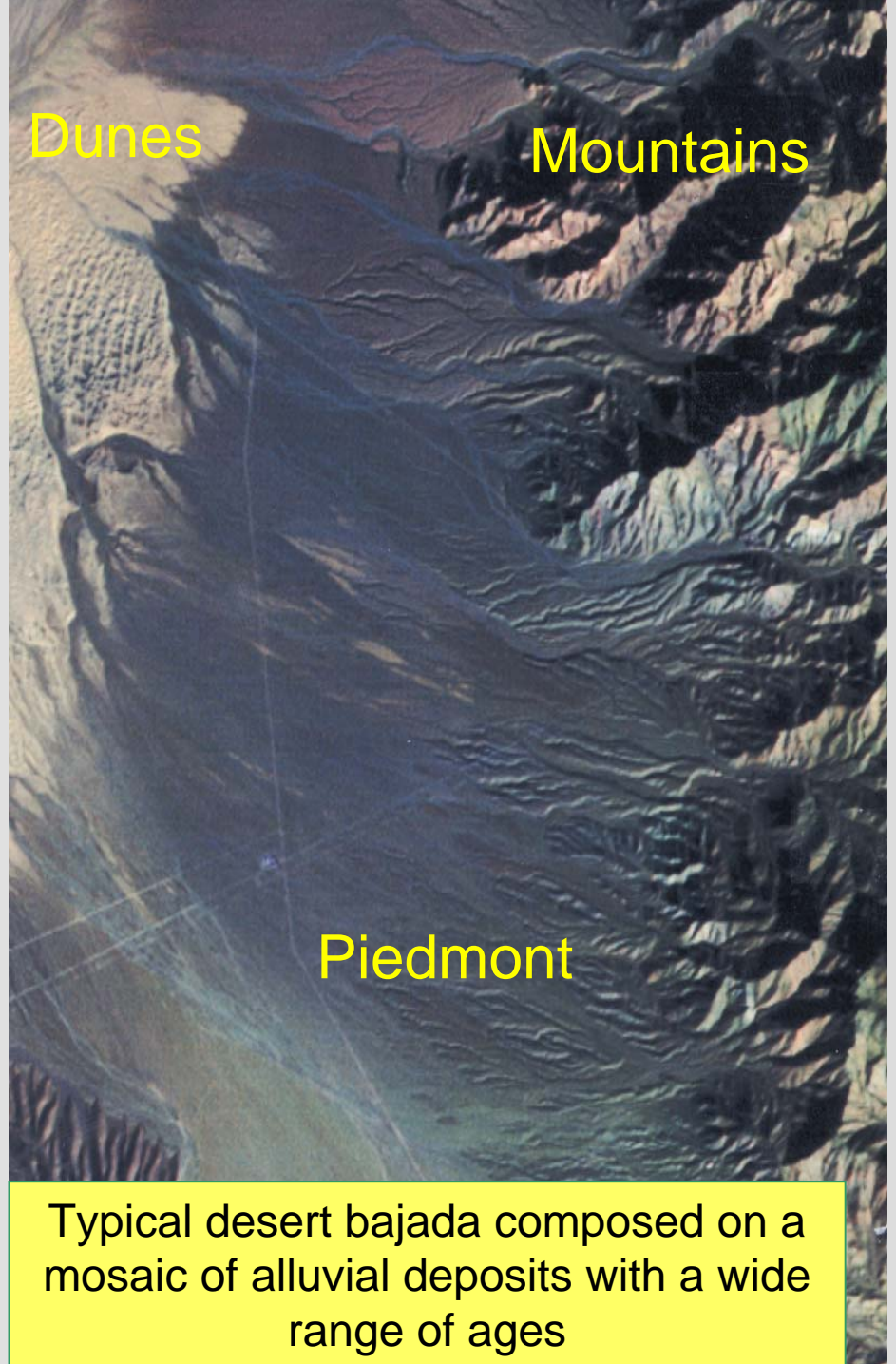
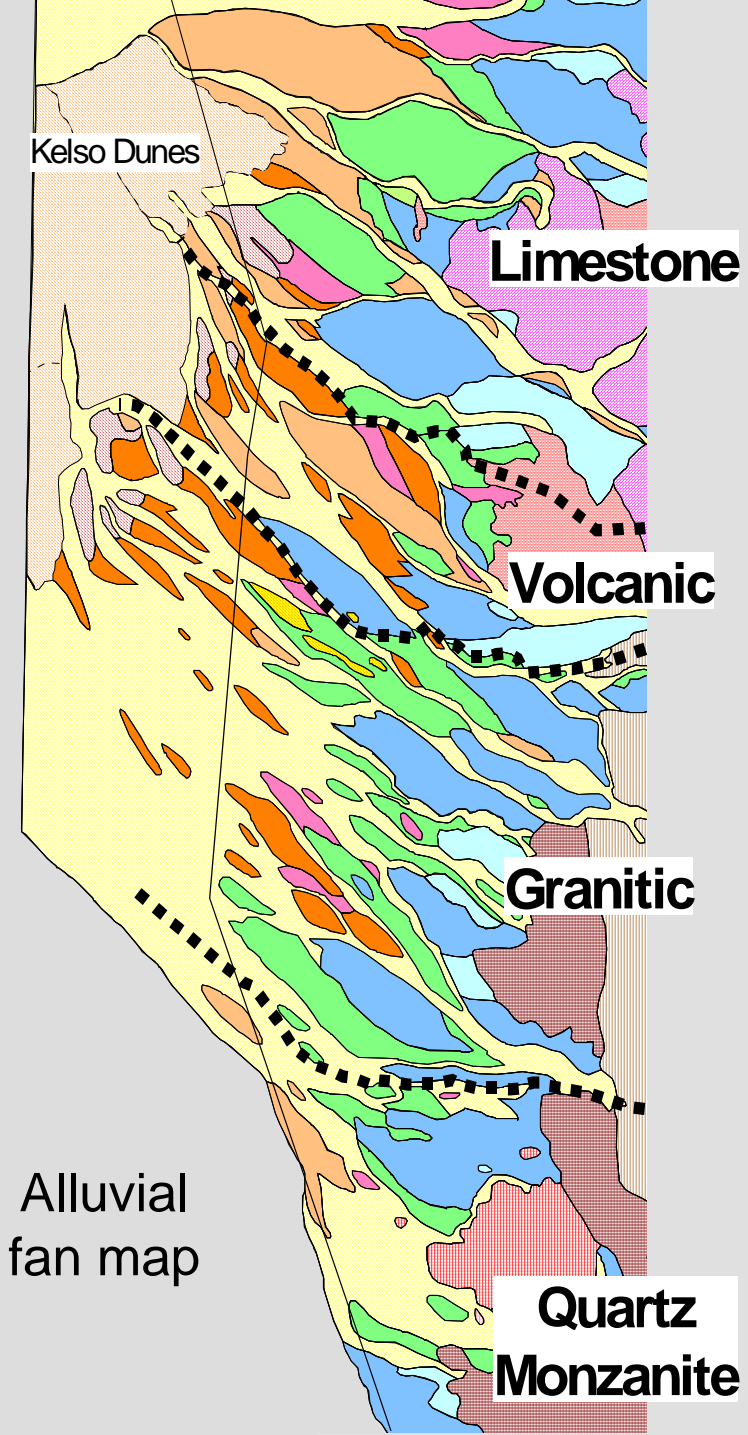
# Key Points of Presentation

- ❖ Alluvial fans contain a range of sediments from cobbles to clays and are capped by soils
- ❖ Alluvial fans can be stacked on top of one another in basins
- ❖ Climate change is frequent and regularly and drives alluvial and lacustrine deposition in deserts

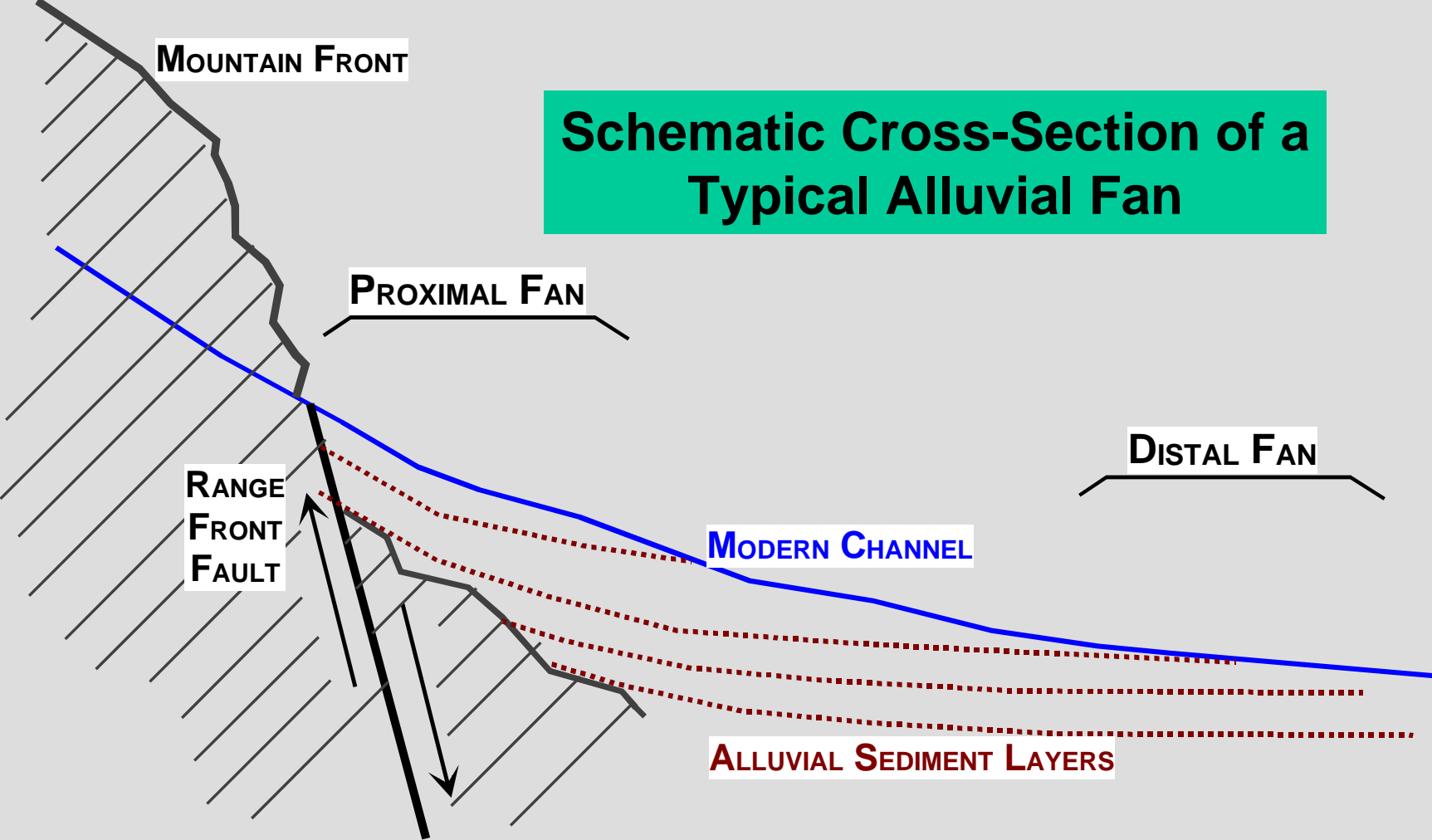
# Outline

- ❖ General character of:
  - alluvial fan deposits
  - Surface and buried soils
  - Control on infiltration
- ❖ Deposition of alluvial fans are regional events:
  - Fans deposited <25 ka
  - Fans deposited <75 ka
- ❖ Fan deposition related to climate change



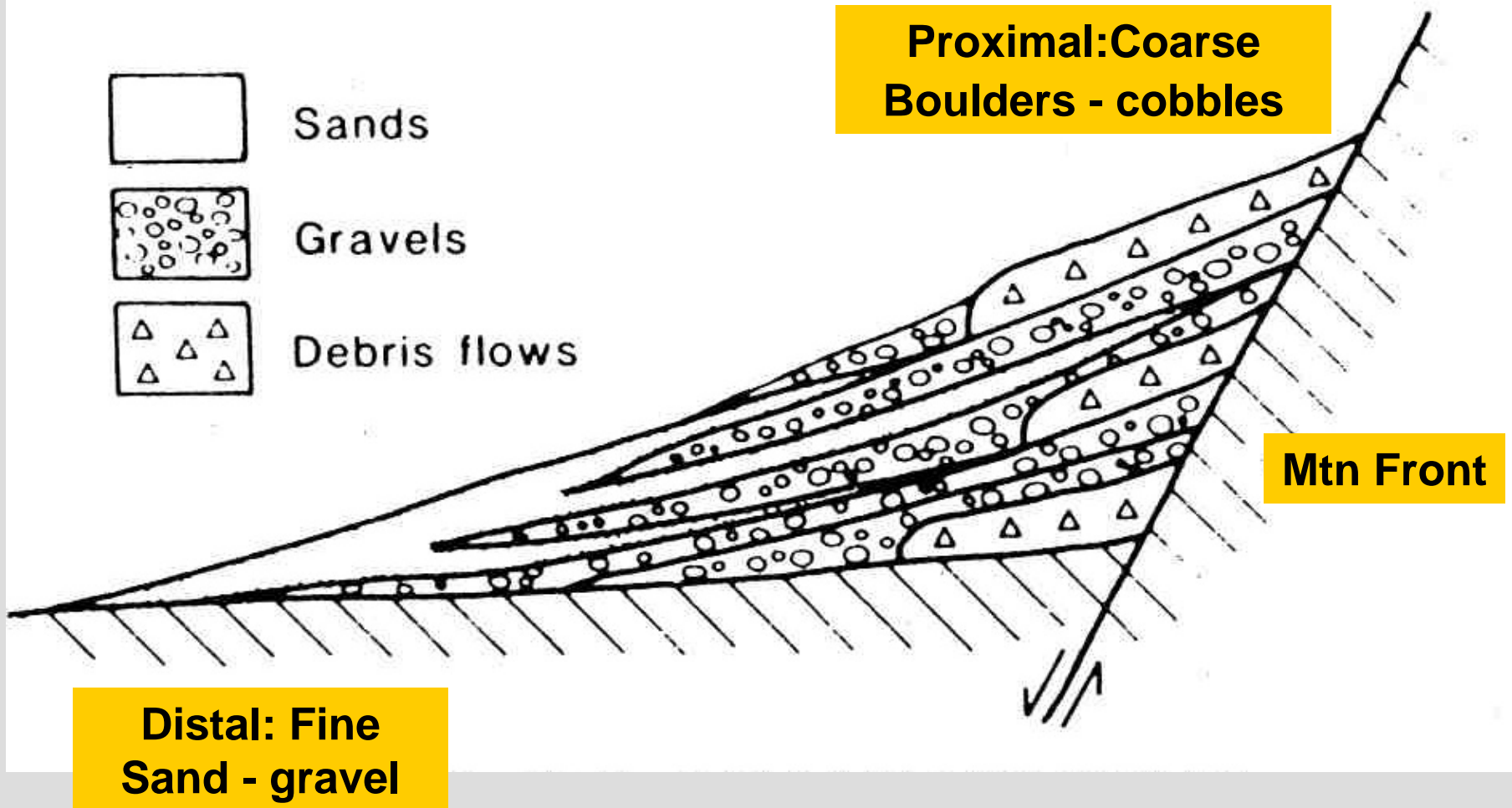


# Schematic Cross-Section of a Typical Alluvial Fan



# PROXIMAL-DISTAL FACIES VARIATIONS

## (c) SCHEMATIC MODEL





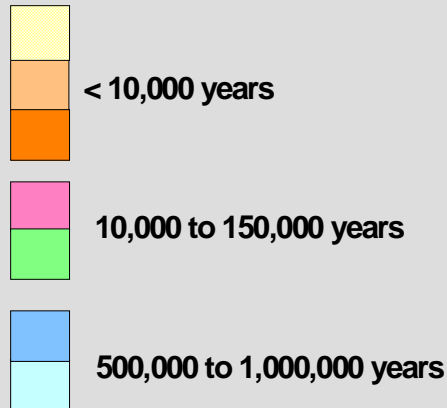
Proximal Fan Sediment:  
Coarse: boulders-cobbles  
Poorly sorted



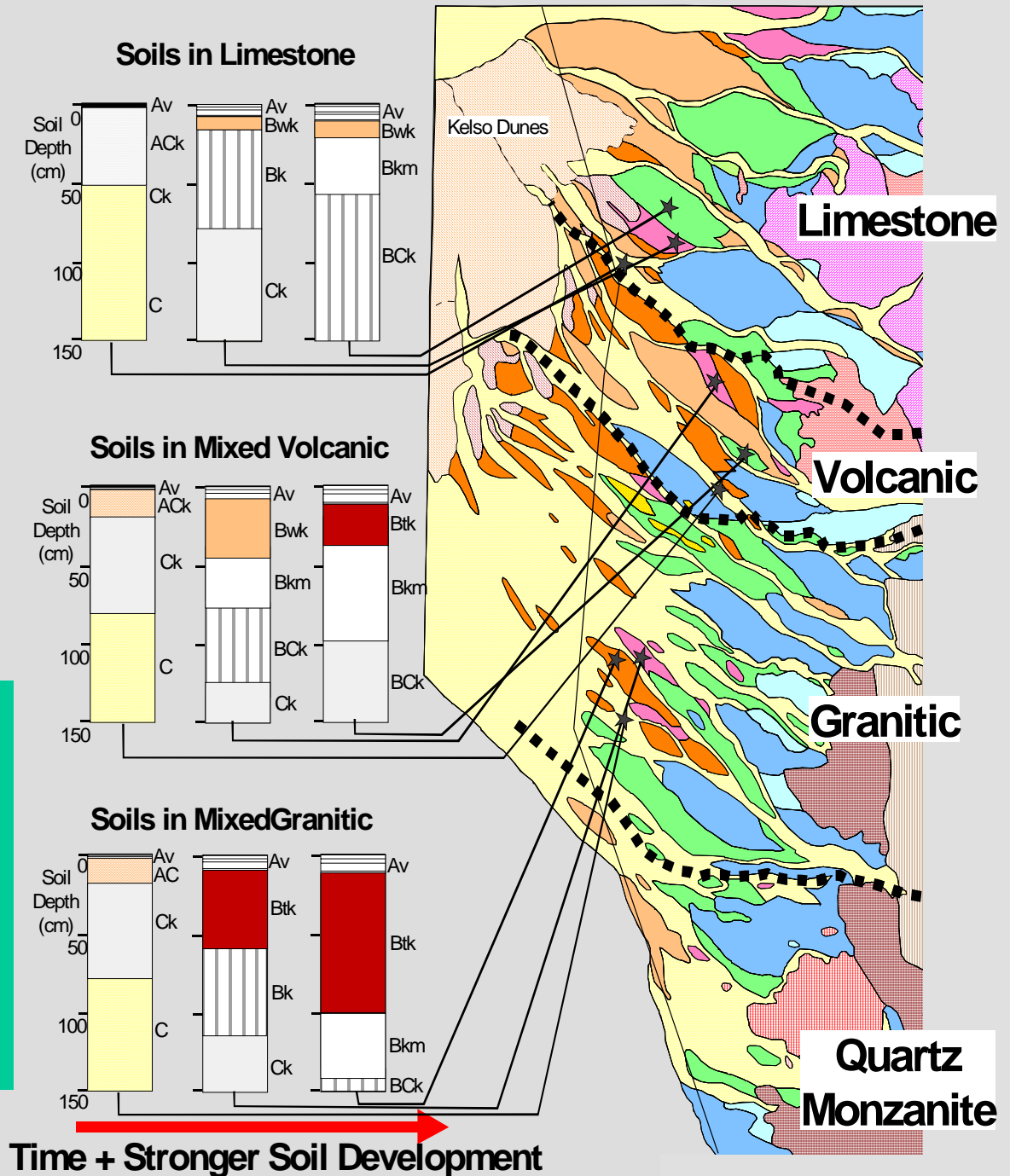
Distal Fan Sediment:  
Fine: cobbles-gravel-sand  
Moderately sorted



## Age of Alluvial Fan Deposits



The degree of soil development will vary with surface age and sediment type (texture and lithology)





**Weak Soil  
Development**

- ❖ **Young deposits**  
( $< 10$  ka)
- ❖ **Sand-rich texture**
- ❖ **Limited Horizonation**
- ❖ **Loose matrix**
- ❖ **High Infiltration**



**Strong Soil  
Development**

- ❖ **Old Deposits**  
( $> 10$  ka)
- ❖ **Clay-rich texture**
- ❖ **Complex Horizonation**
- ❖ **Cemented matrix**  
(Carbonate, silica)
- ❖ **Low Infiltration**

# Typical Types of Soils on Alluvial fans



**Holocene  
( $<10\text{ka}$ )  
Weak  
Carbonate  
Accumulation**

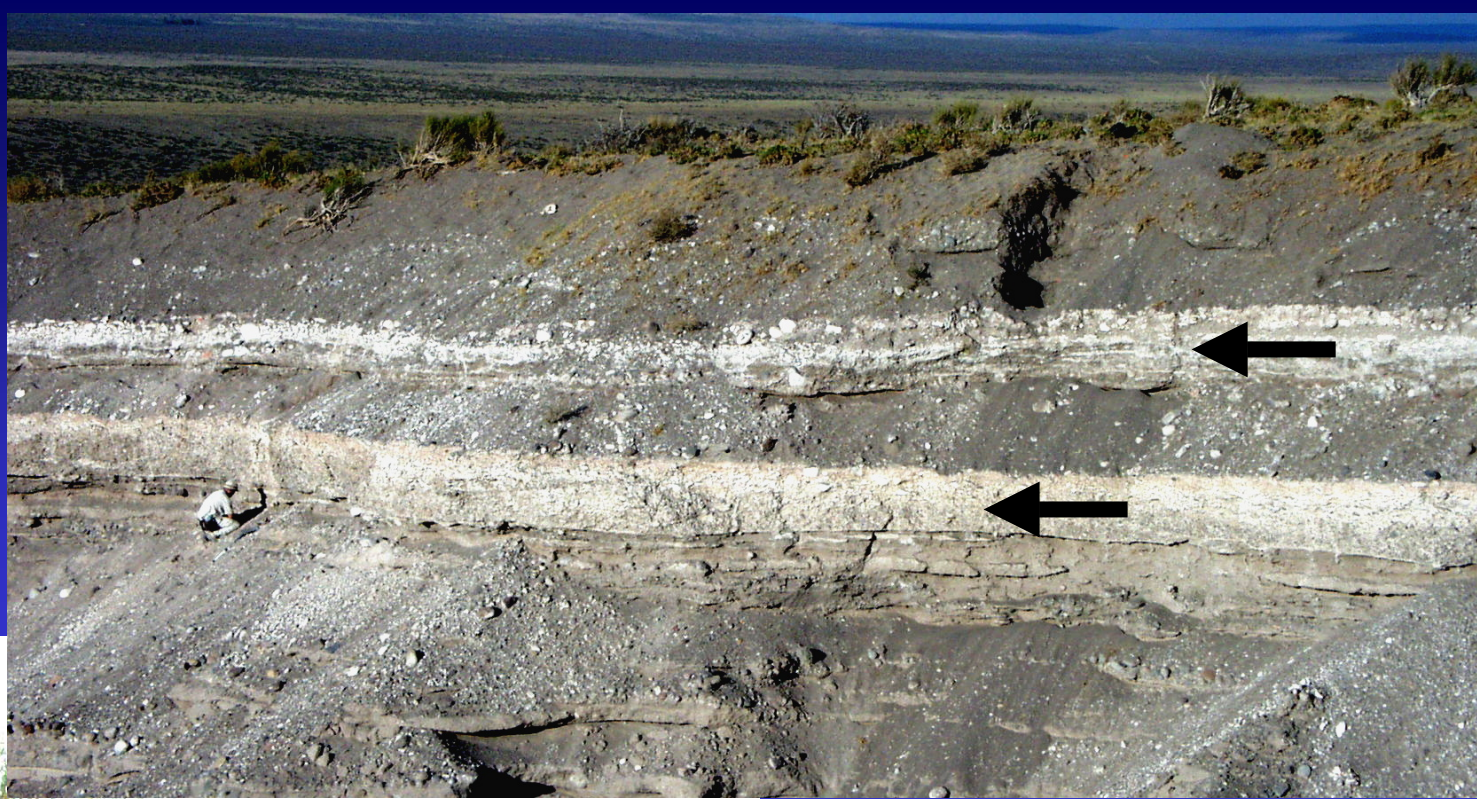


**Pleistocene  
( $10-100+\text{ka}$ )  
Strong Clay  
Accumulation**



**Pleistocene  
( $10-100+\text{ka}$ )  
Strong  
Carbonate  
Accumulation**

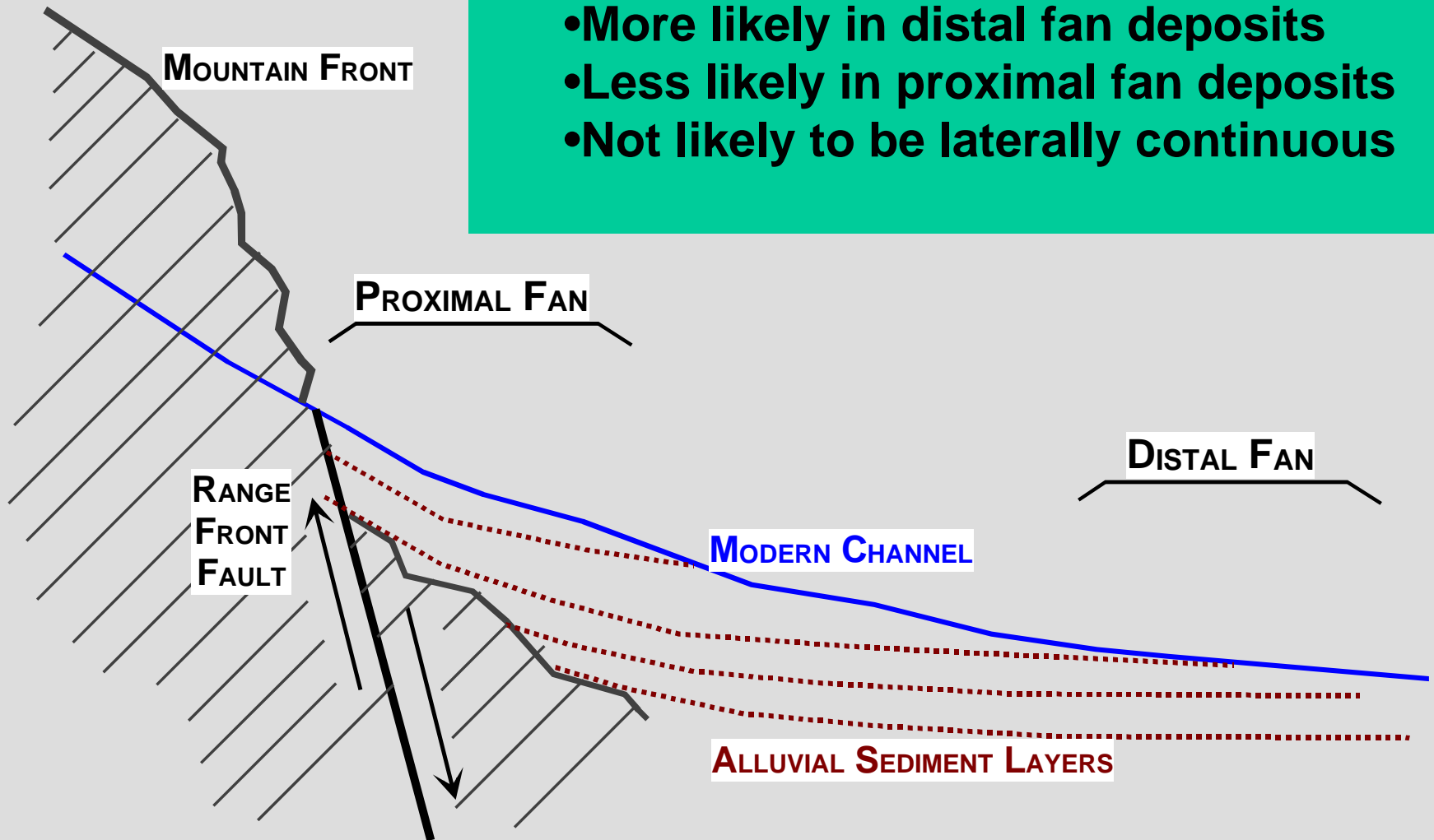
**Abundant Silt and Clay  
from Desert Dust**



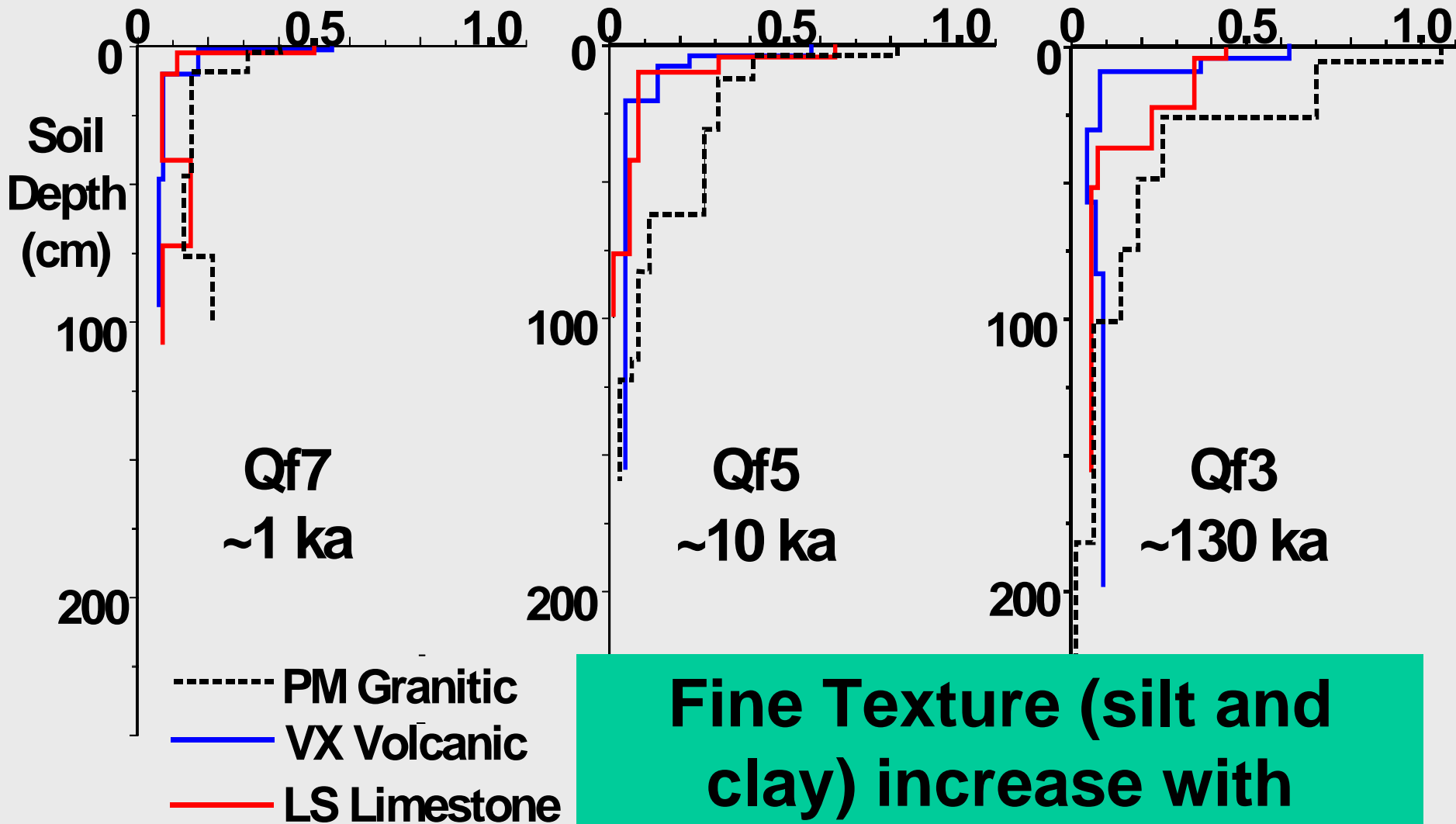
**Examples of  
buried soils in  
alluvial fan  
deposits**

## Buried soils (paleosols):

- More likely in distal fan deposits
- Less likely in proximal fan deposits
- Not likely to be laterally continuous

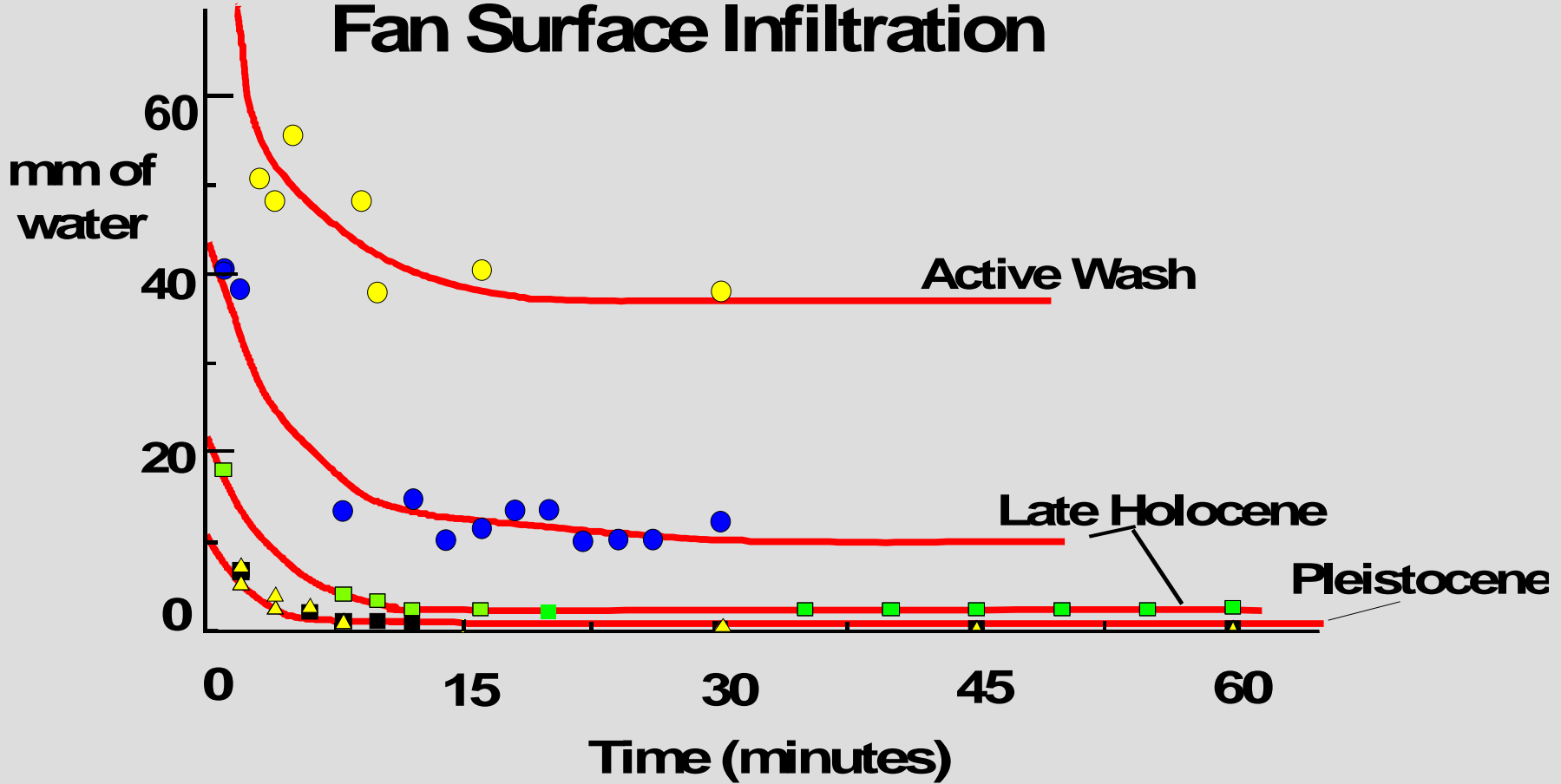


# Depth Profiles of Soil Silt + Clay ( $\text{g}/\text{cm}^3$ )



**Fine Texture (silt and clay) increase with surface age**

# Fan Surface Infiltration



**Infiltration decreases with increasing soil development**



# Outline

## ❖ General character of:

- alluvial fan deposits
- Surface and buried soils
- Control on infiltration

## ❖ **Deposition of alluvial fans are regional events:**

- **Fans deposited <25 ka**
- **Fans deposited <85 ka**

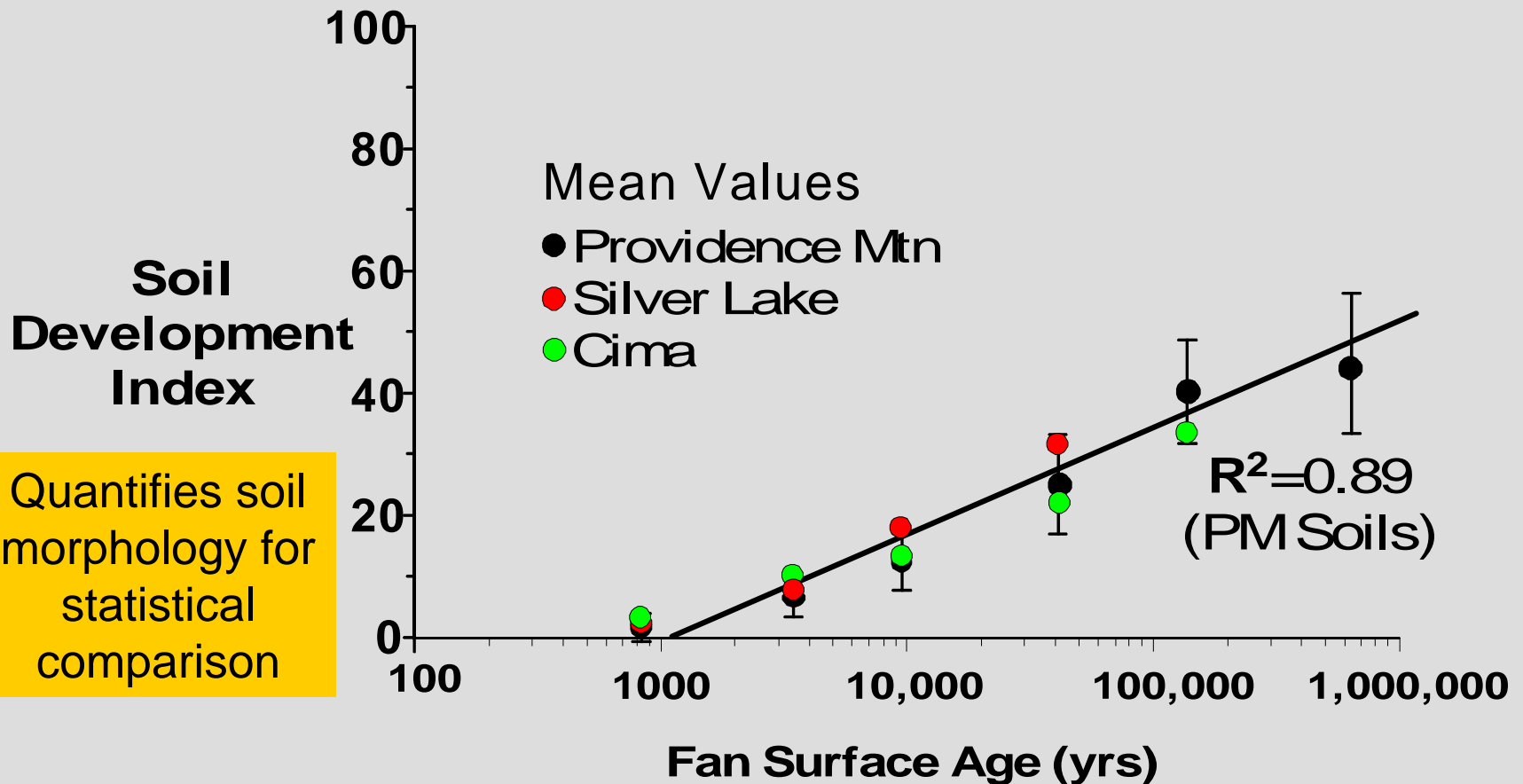
## ❖ Fan deposition related to climate change

# Age Control of Quaternary Units Supports Regional Correlation

PROVIDENCE			SILVER LK.			CIMA			
IRSL Be <sup>10</sup>			C <sup>14</sup>			K-Ar He <sup>3</sup>			
Qf7	ka	ka		Qf5	ka		Qf8	ka	ka
Qe3	3.5 3.7 4.0 4.2								
Qf6				Qf4	3.4		Qf7		
				Qf3			Qf6		
Qe2	8.4			Qe2					
Qf5	10.4 12.5	8 18		Qf5	8.4 9.2 10.3 14.6		Qf5		
Qe1	16.8 17.3			Qe1	<20.3		Qv6		18 20
Qf4				Qf4			Qf4		
								60 90	
Qf3		76 84					Qf3		80 85
							Qv4	130	65 74
							Qv3	150 170	

Ages in ka (=X 1000 years before present)

# Regional Correlation of Alluvial fan Deposits Using Soil Development



# Outline

## ❖ General character of:

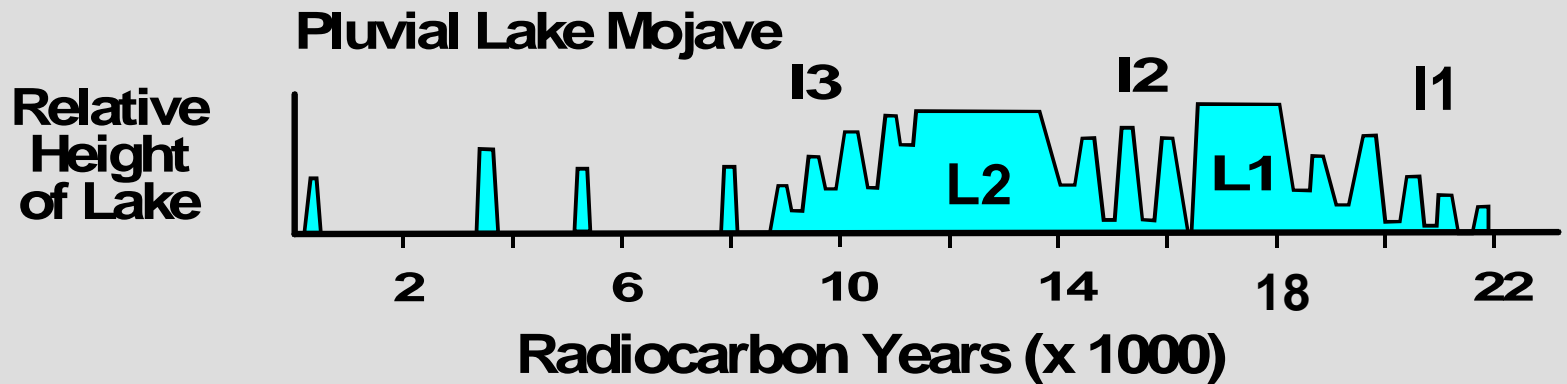
- alluvial fan deposits
- Surface and buried soils
- Control on infiltration

## ❖ Deposition of alluvial fans are regional events:

- Fans deposited <25 ka
- Fans deposited <85 ka

## ❖ **Fan deposition related to climate change**

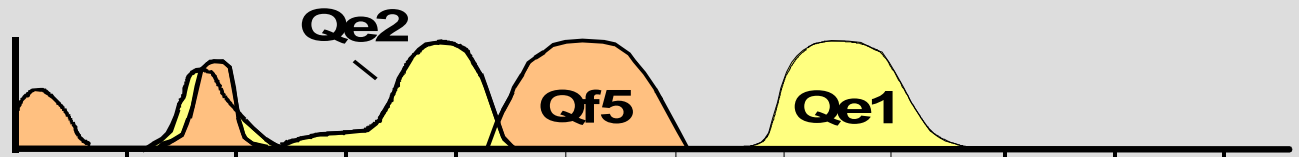
# Climate Record Preserved in Pluvial Lake Sediments



# Climate Record Compared with Periods of Alluvial Fan Deposition

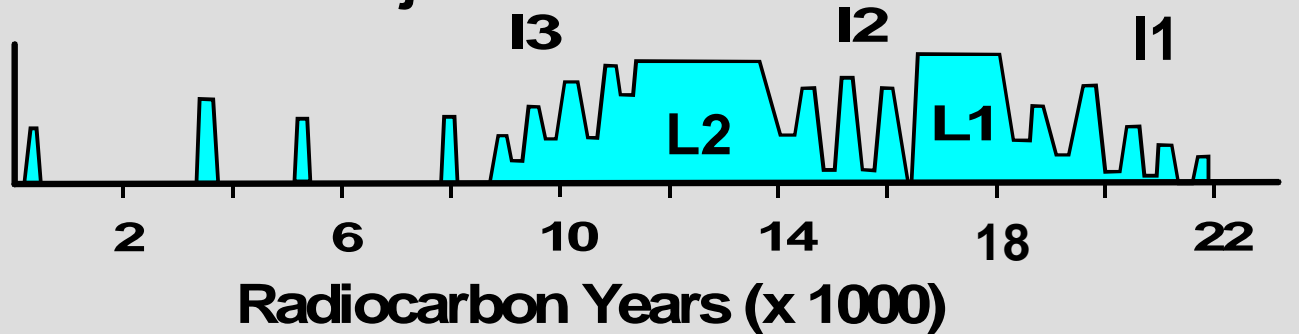
Fan and Eolian  
Deposition

Providence Mountains



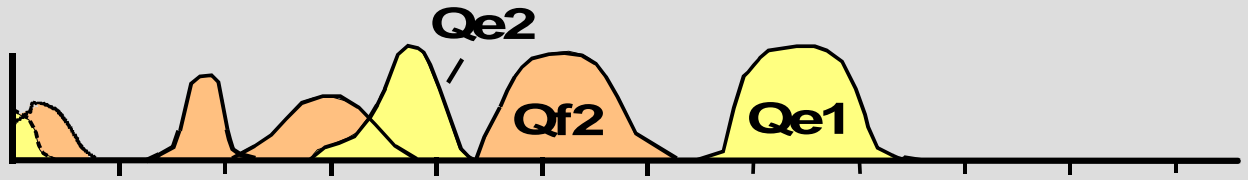
Pluvial Lake Mojave

Relative  
Height  
of Lake



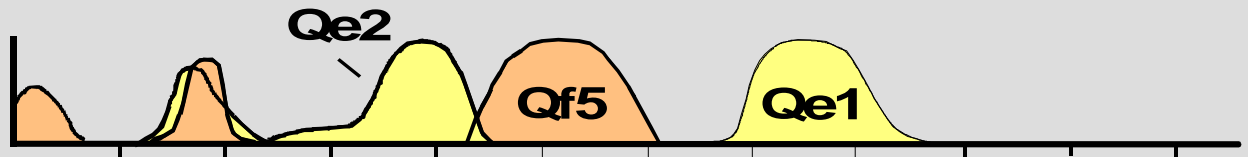
# Similar Record of Alluvial Fan Deposition Across the Region

## Silver Lake Playa / Soda Mountains



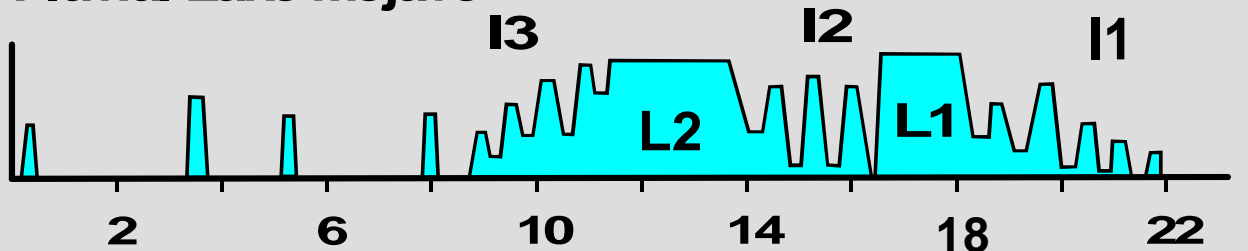
Fan and Eolian  
Deposition

## Providence Mountains



## Pluvial Lake Mojave

Relative  
Height  
of Lake



Radiocarbon Years (x 1000)

# Drainage Basin Comparison:

## Providence:

High elevation

Semi arid - subhumid

Continuous vegetation cover

## Soda:

Low elevation,

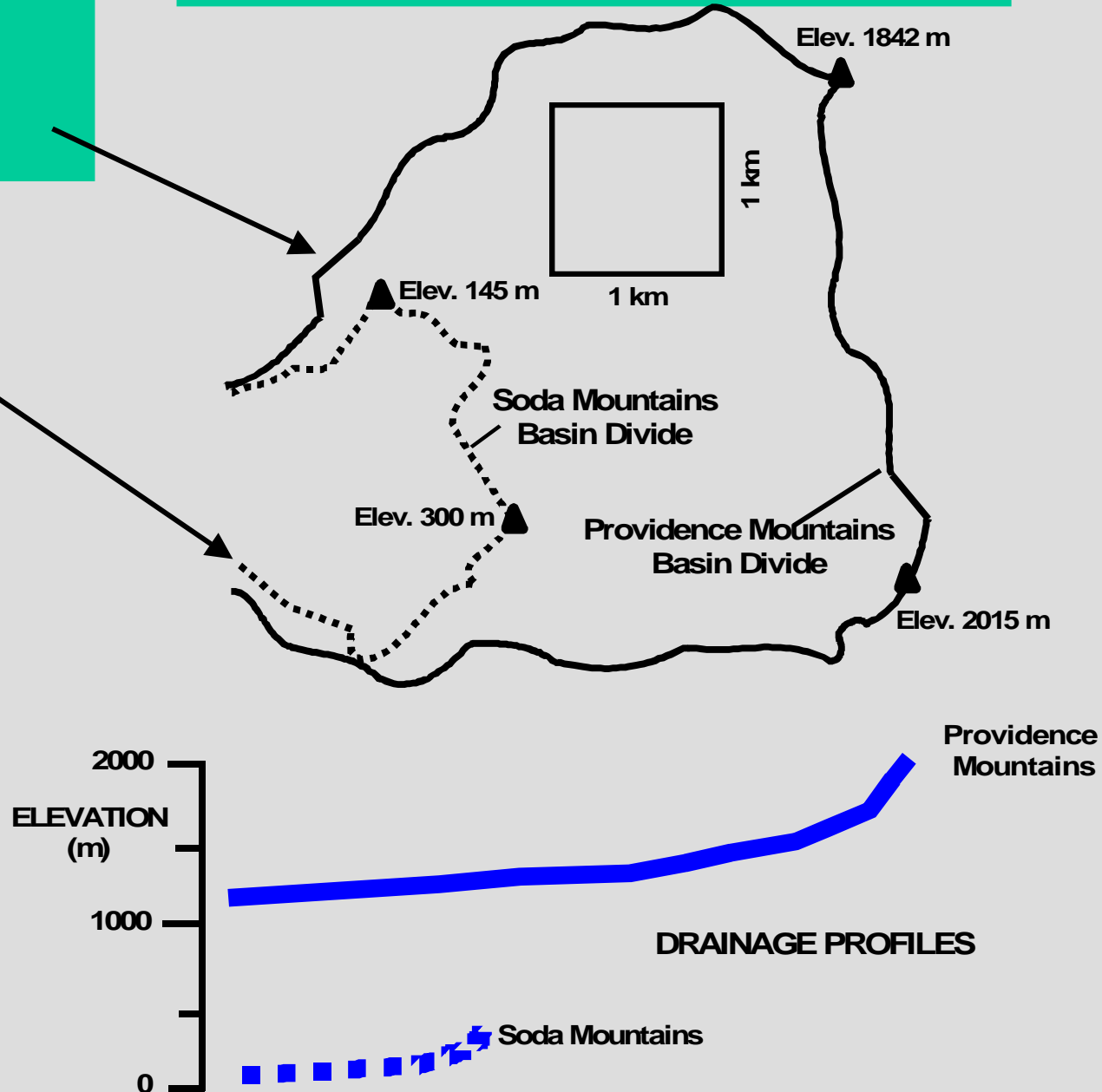
Arid

Sparse vegetation cover

Considerable  
Differences in  
Basin Environment

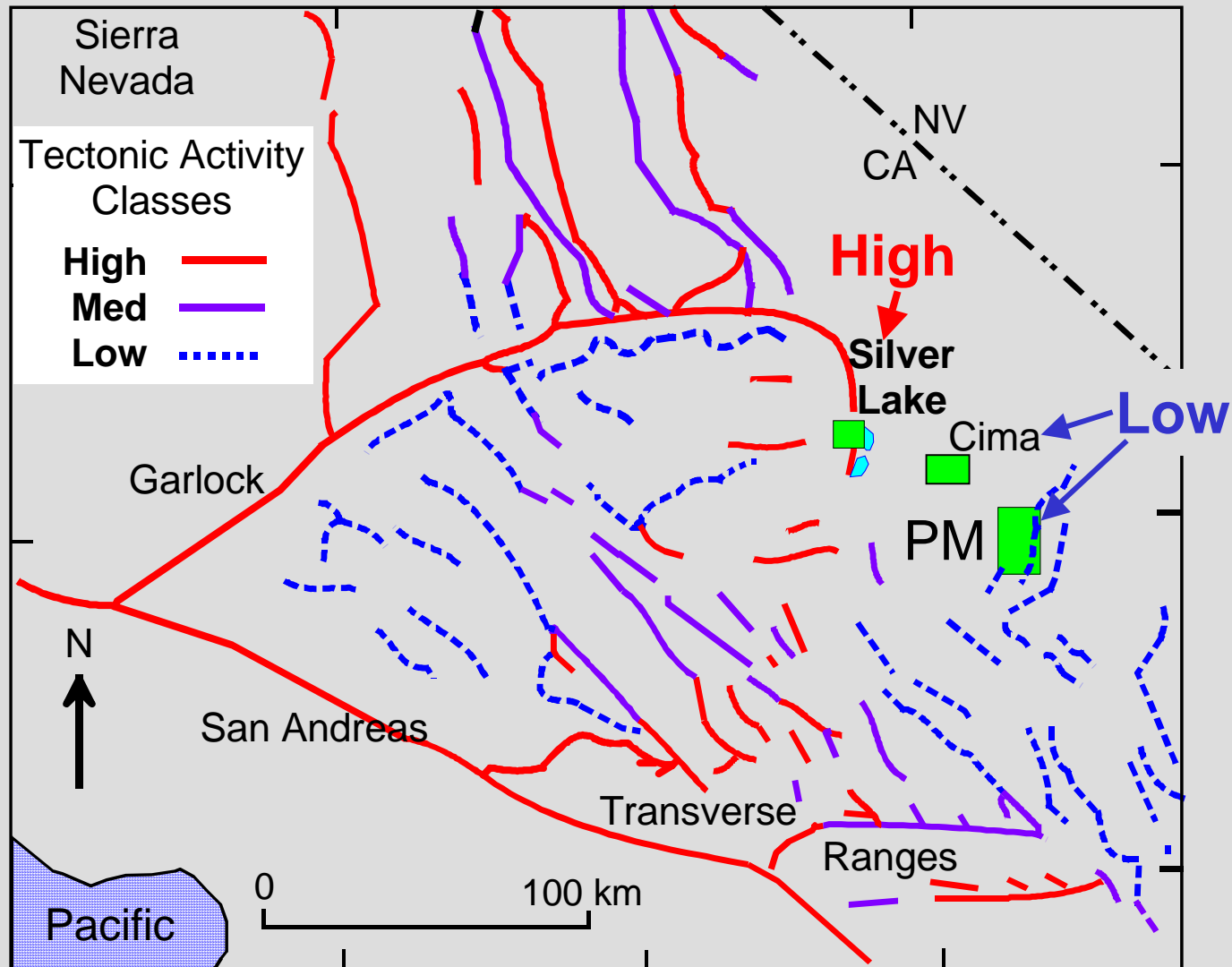
*However:*

Similar history of  
alluvial fan  
deposition



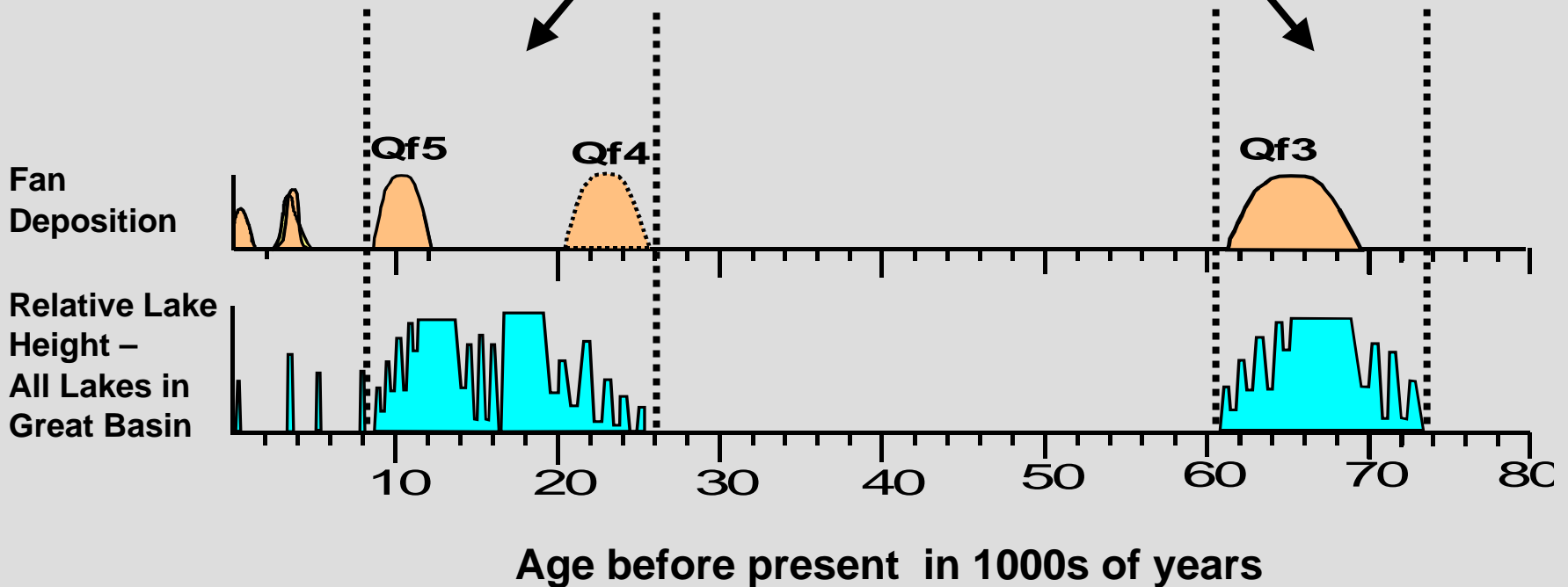


# Alluvial Fan Record Similar Across All Levels of Tectonic Activity: Indicates Regional Climate Change Controlling Major Periods of Fan Deposition

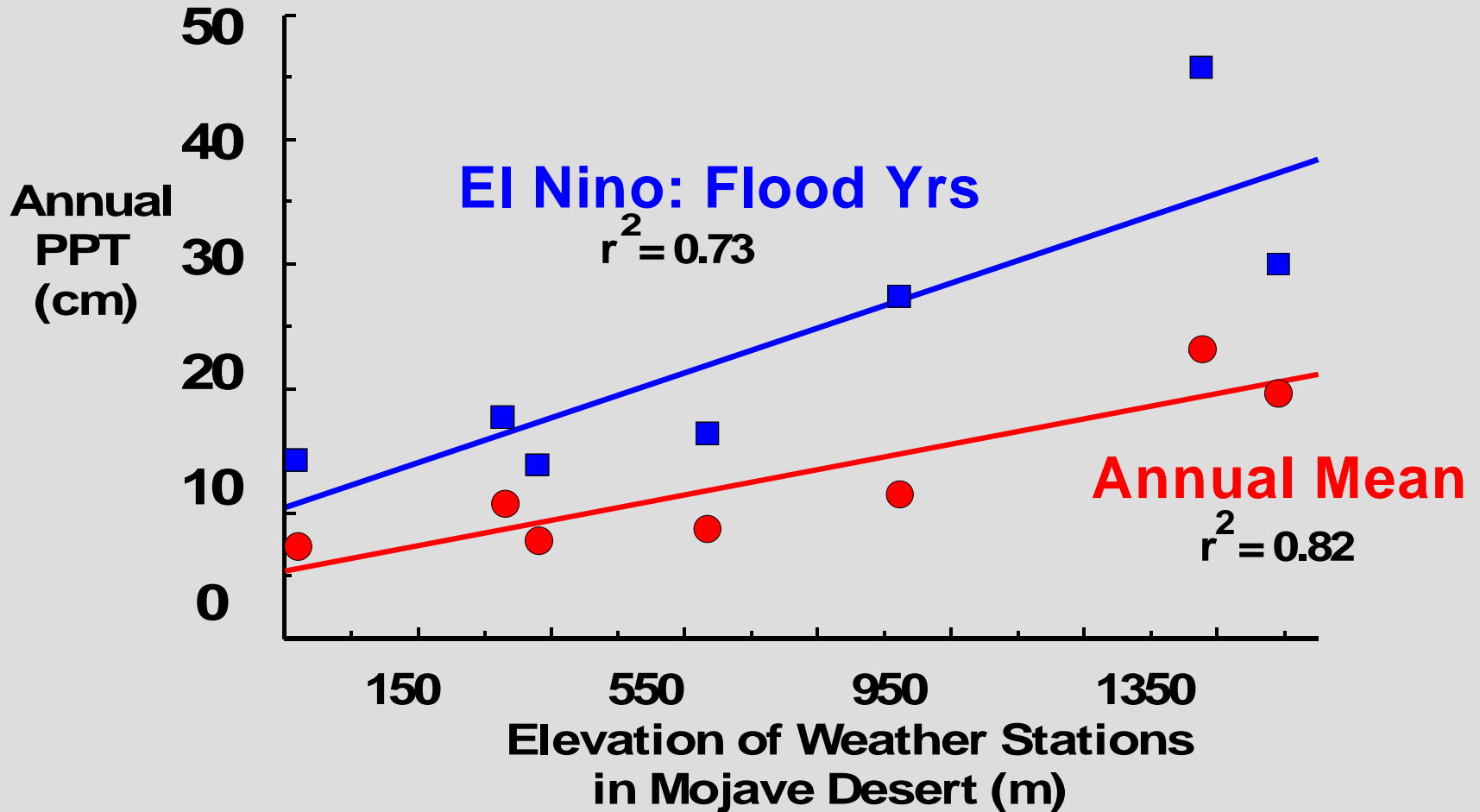


# Regional Record of Lake and Alluvial Fan Activity: Last 80 ka

Period of Major Glacial and Lacustrine Activity in North America

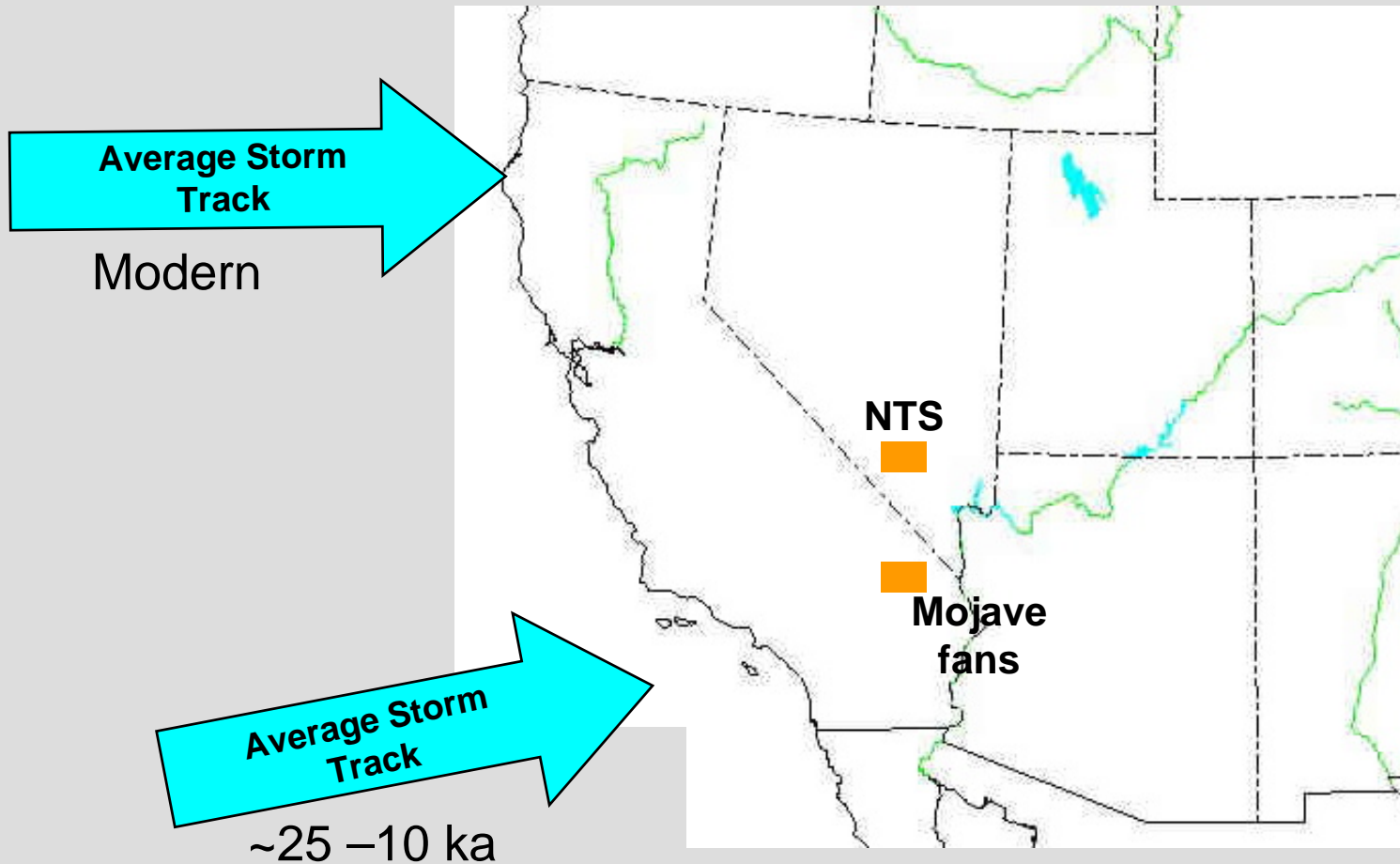


# ANNUAL PRECIPITATION MOJAVE DESERT



Regional Increase in ppt during pluvial cycles

# Alluvial Fans Deposited During Intervals of Increased Storm Activity



# Summary of Alluvial Fan Record

- ❖ Alluvial fans contain a range of sediments from cobbles to clays and are capped by soils
  - Soil development (silt, clay, carbonate) increases with surface age
  - Infiltration decreases with surface age
- ❖ Alluvial fans can be stacked on top of one another in basins
  - Stacked sequence of fan deposits
  - Contains buried soils, but preservation discontinuous, best in distal areas
- ❖ Climate change is frequent and regularly and drives alluvial and lacustrine deposition in deserts
  - Distinct periods of region-wide alluvial fan deposition
  - Across a wide range of environmental and tectonic settings
  - Alluvial fan deposition related to some aspect of climate change
  - At least 5 major periods of fan deposition in the last ~75 ka
  - Questions remain about how climate change drives fan deposition