

Slip Rates on Young faults



Students use reported ages and offset (including uncertainty) of quaternary surfaces to calculate vertical slip rates of a young fault to determine if slip rates have varied significantly through time

Audience:

Undergraduate class in Quantitative Reasoning and/or structure and/or tectonics

- Skills and concepts that students must have mastered: Familiarity with faults, slip rates, uncertainty.
- This is a stand-alone exercise that can be started in class (~30-50 min to get students started), and completed outside of class

Goals:

Content, concept goals for this activity:

- exposure to using real data (real data is messy)
- Exposure to how we use real data to infer rates of geologic processes
- Practice making calculations
- Practice plotting data (with uncertainty)
- Practice propagating uncertainty

Goals:

Higher order thinking skills/goals for this activity:

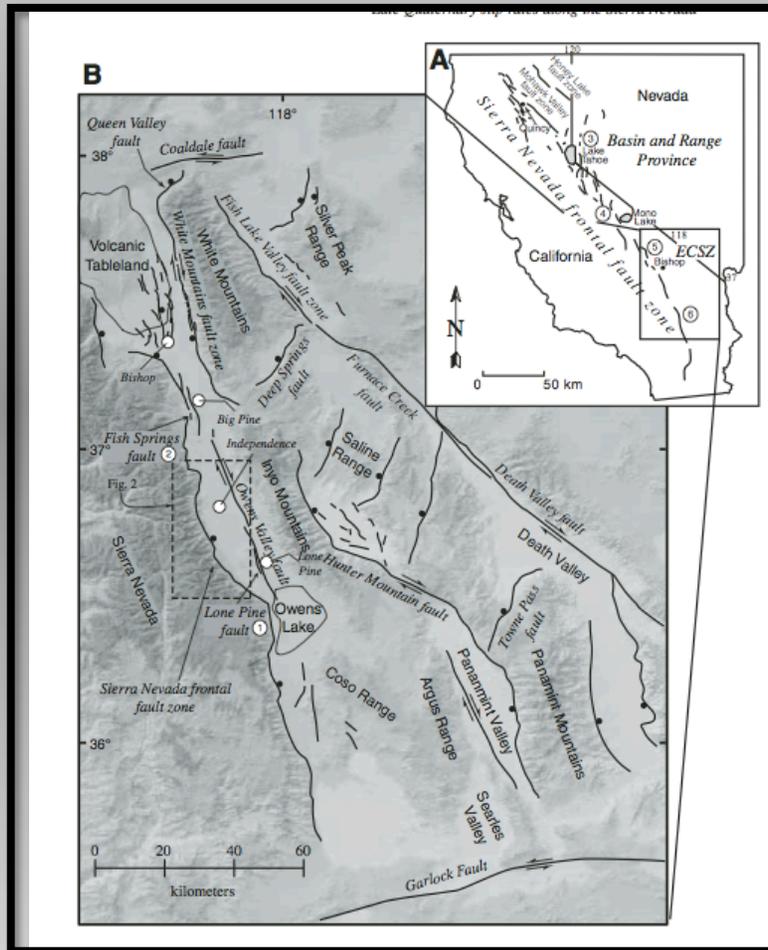
- understand uncertainty associated with measurements,
- importance of incorporating uncertainty when evaluating data

Goals:

Higher order thinking skills/goals for this activity:

- Compare local, short-term, deformation rates to large-scale, long-term deformation rates
- Incorporate incomplete data
- Discussion of precision (reported uncertainty) versus accuracy. i.e., does the dating and offset measurements really capture the surface ages and actual offset

Introductory material: map and tectonic setting of SNFFZ fault

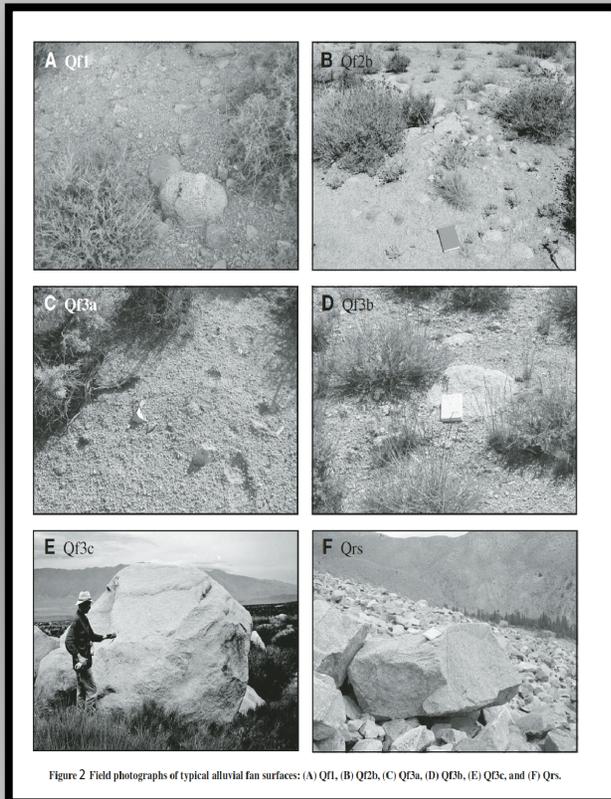


Region where strike-slip of San Andreas associated deformation overlaps with normal faulting of Basin and Range associated deformation

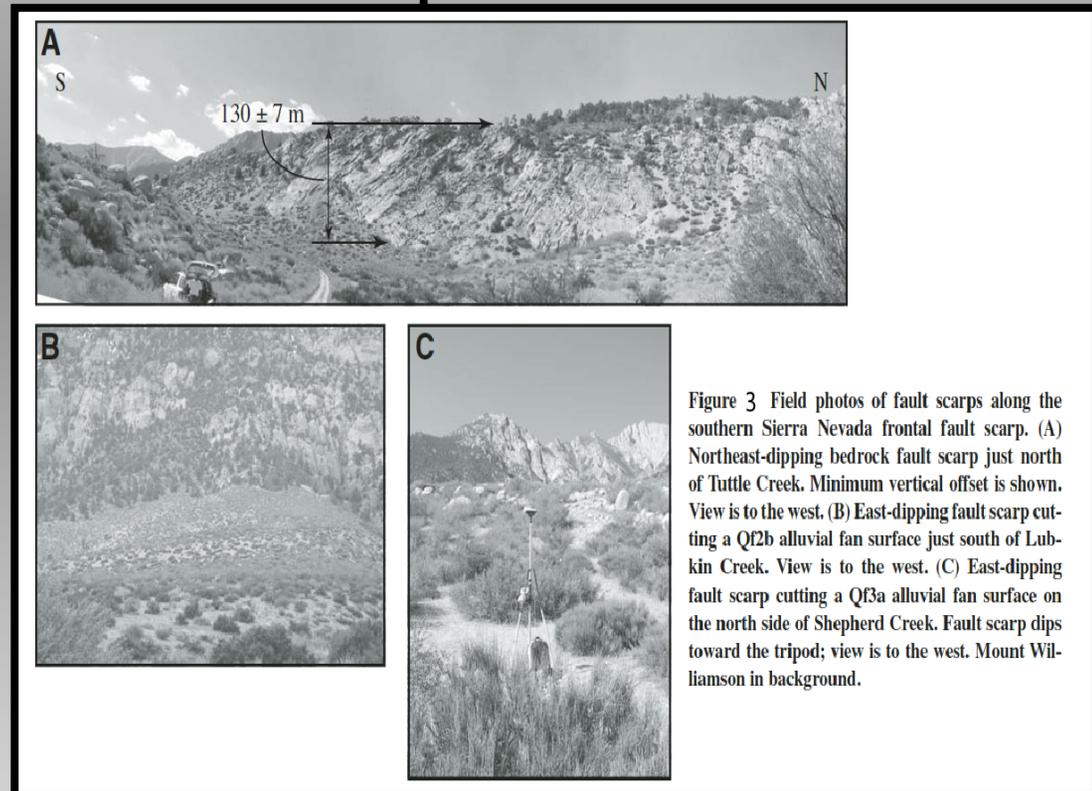
Question:
Did the rate of (vertical) fault offset change through time?

The Data

- Quaternary surfaces: dated by cosmogenics



- Fault scarps and fault offset



Summary of data

Surface	Age (ka)	Vertical offset of dated surface (m)	Maximum vertical offset (m)
Q1	120 ± 20 ka	24 ± 1	—
Q2a	Q1 > Q2a > Q2b	—	41 ± 2
Q2b	61 ± 7	11.9 ± 0.6	—
Q3a	26 ± 8	10.2 ± 0.5	10.2 ± 0.5
Q3b	Q3a > Q3b > Q3c	—	6.4 ± 0.3
Q3c	4 ± 1	—	6.9 ± 0.3

Table 1: Summary of Surface Ages and Vertical offsets (from Le et al, 2007)

Uncertainties are ± 1 s

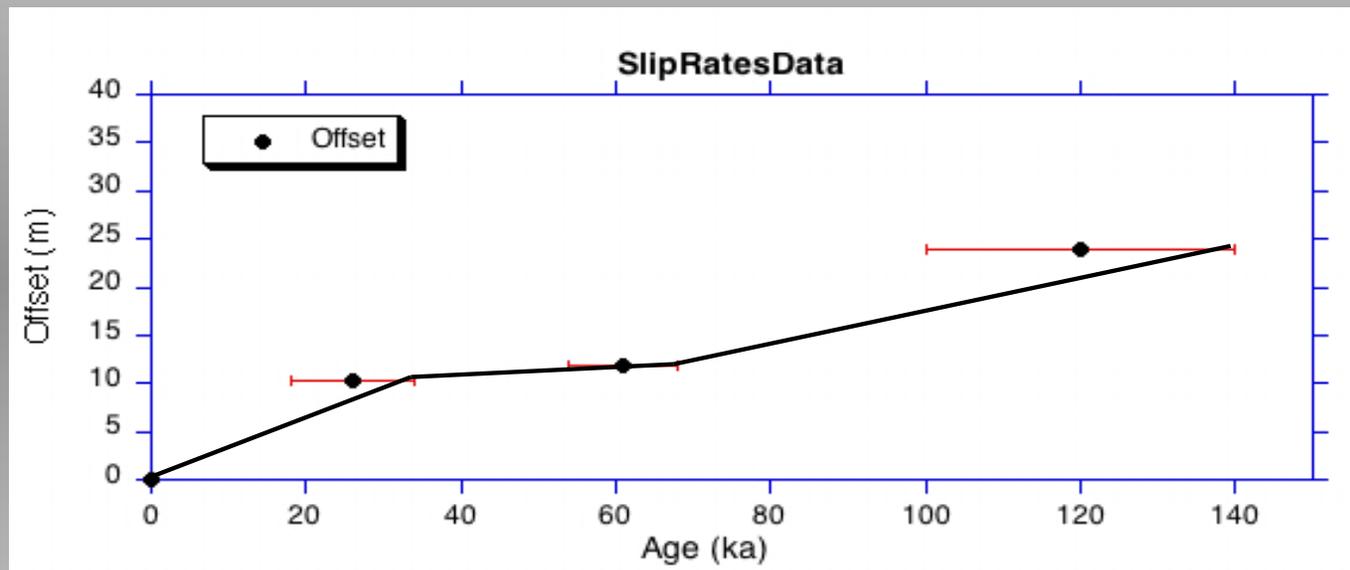
Table includes 6 surfaces, but only three have measured ages and offset (remaining 3 have incomplete data)

Data Analysis: Calculations

Time span	Slip rate (m/ka)	Fractional Uncertainty in slip rate (%)	Slip rate and Uncertainty (m/ka)
120 → 61 ka	0.20	59	0.20 ± 0.12
61 → 26 ka	0.05	108	0.05 ± 0.05
26 ka → present-day	0.39	36	0.39 ± 0.14

Propagating uncertainty based on *An introduction to error analysis*, John Taylor

Data Analysis: Graphing

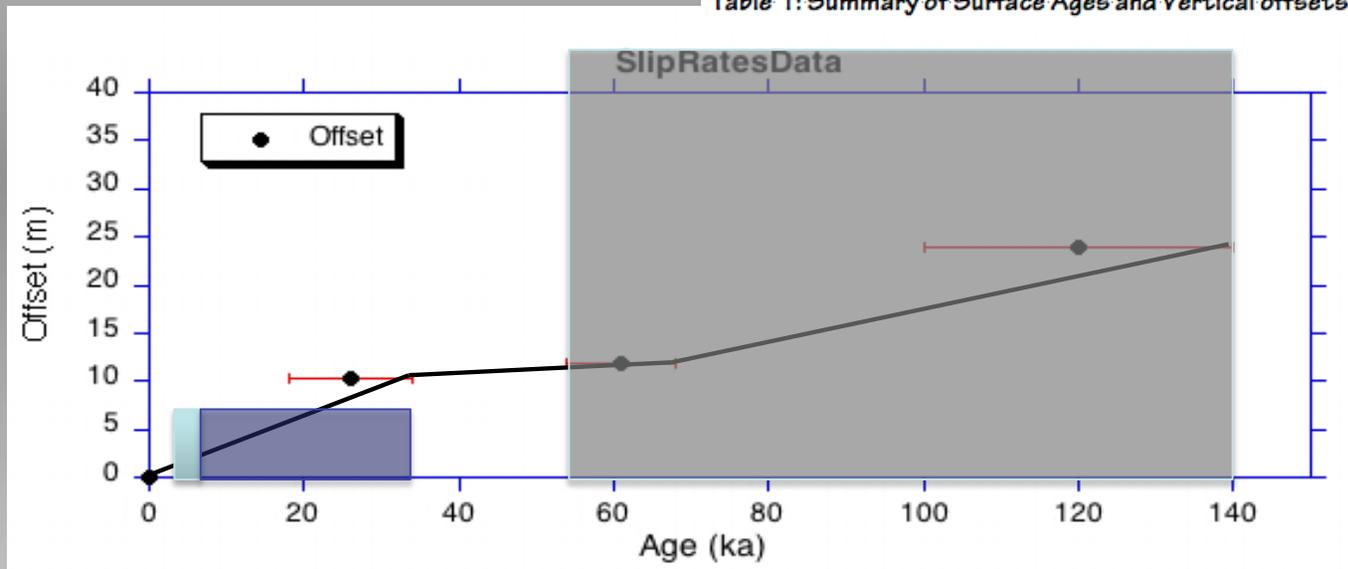


- Incorporate $\text{offset}=0$ at $\text{time}=0$
- Determine rates through time
- Determine range of slopes (range of rates)

Data Analysis: Graphing

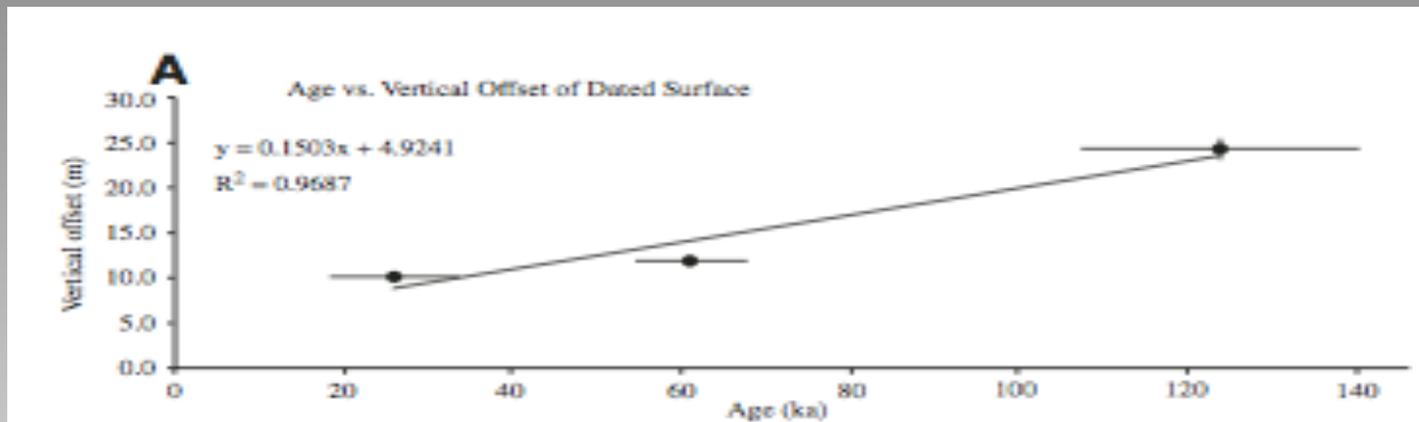
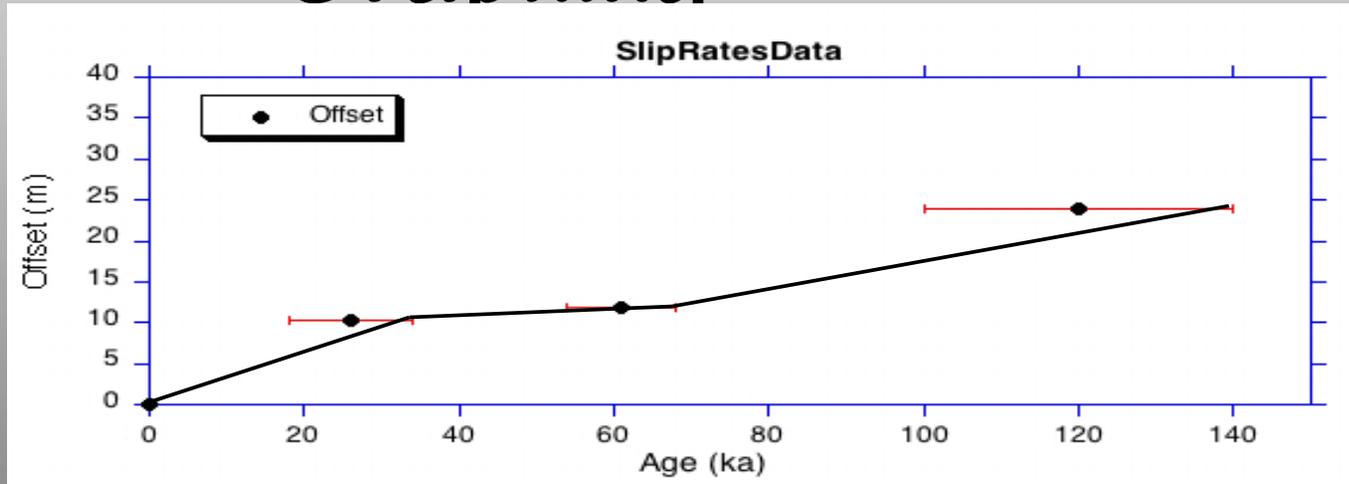
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Table 1: Summary of Surface Ages and Vertical offsets (from Le et al, 2007)



-Include incomplete data- how to deal with and utilize incomplete data

Data Analysis: Graphing



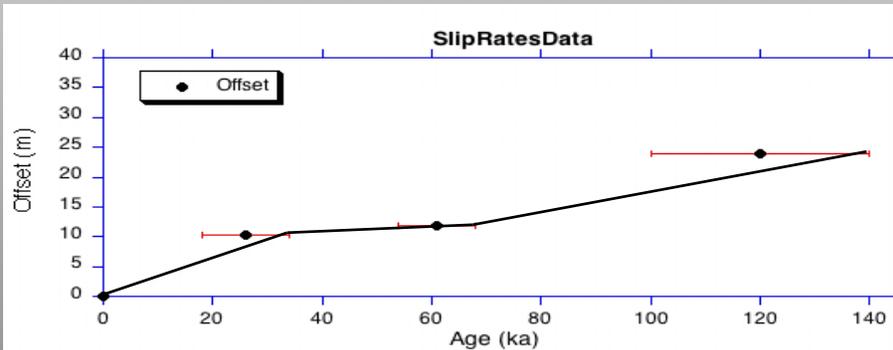
-Compare to published conclusions

7/18/12

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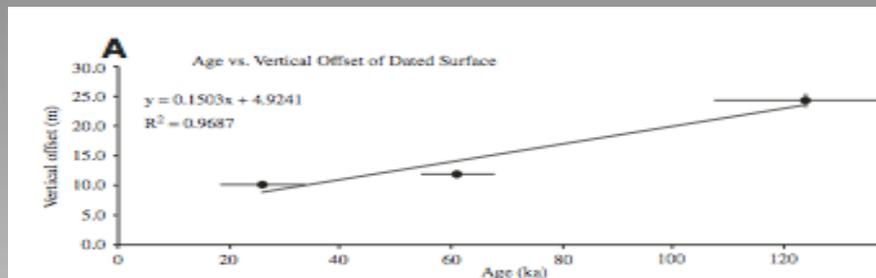
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Data Analysis: Graphing



Qf2b Surface Age	
Sample	^{10}Be age \pm error
K2*	89.2 \pm 2.1
K3	53.4 \pm 1.7
K4*	23.1 \pm 0.9
K5	66.0 \pm 2.2
K6	63.2 \pm 2.3
Mean age 60.9 \pm 6.6 ka	

Qf3a Surface Age	
Sample	^{10}Be age \pm error
K12	36.6 \pm 0.8
K13	23.5 \pm 0.5
K14	17.6 \pm 0.5
K15	29.9 \pm 0.9
K16	21.2 \pm 0.5
Mean age 25.8 \pm 7.5 ka	

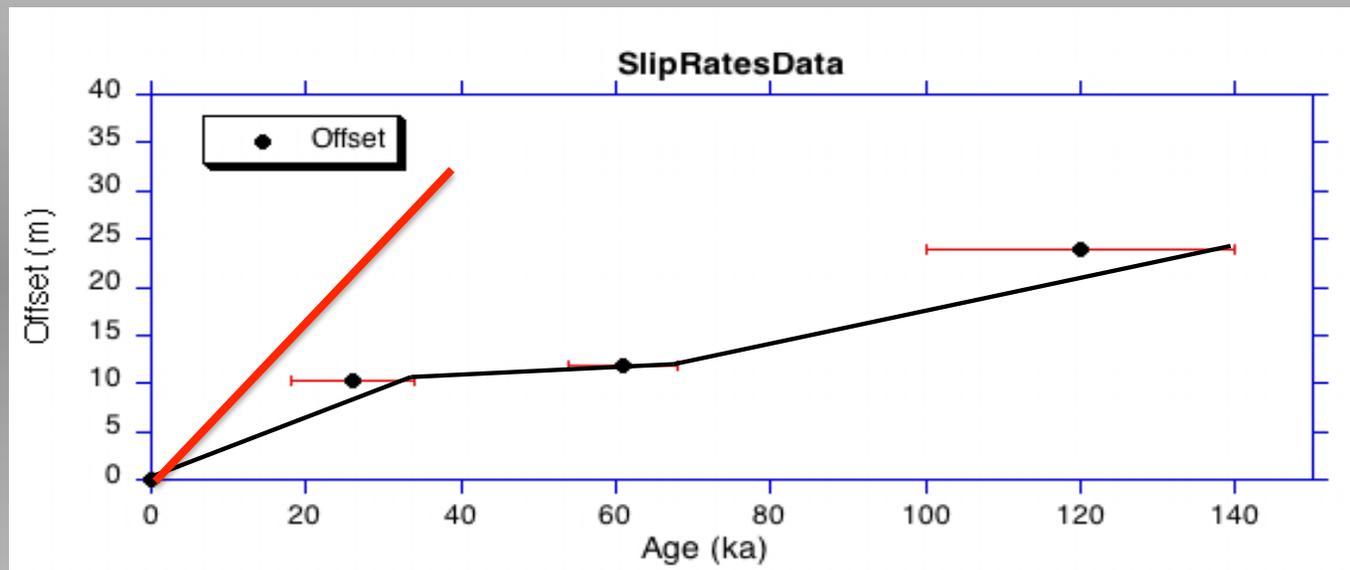


Qf3c Surface Age	
Sample	^{10}Be age \pm error
K7	6.0 \pm 0.2
K8	4.1 \pm 0.2
K9	3.1 \pm 0.2
K10	3.7 \pm 0.6
K11	5.0 \pm 0.2
Mean age 4.4 \pm 1.1 ka	

Qf4 Surface Age	
Sample	^{10}Be age \pm error
K17	4.0 \pm 0.2
K18	4.3 \pm 0.1
K19	4.0 \pm 0.2
Mean age 4.1 \pm 1.0 ka	

- Compare to published conclusions=>
- Uncertainties \pm 1 sigma
- Precision vs Accuracy

Data Analysis: Graphing



- compare to long-term, large-scale rates:
- Vertical component of plate-rates (20 cm/year) along 60° fault (converting between cm/year and m/ka)

Slip Rates on Young faults



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Late Quaternary slip rates along the Sierra Nevada frontal fault zone, California: Slip partitioning across the western margin of the Eastern California Shear Zone–Basin and Range Province

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