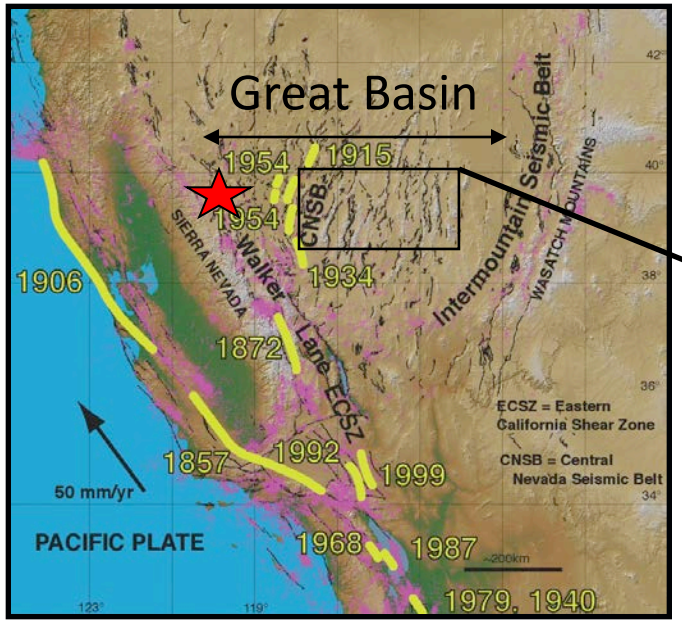
Mapping tectonic faults from geomorphology
Normal faults part 3

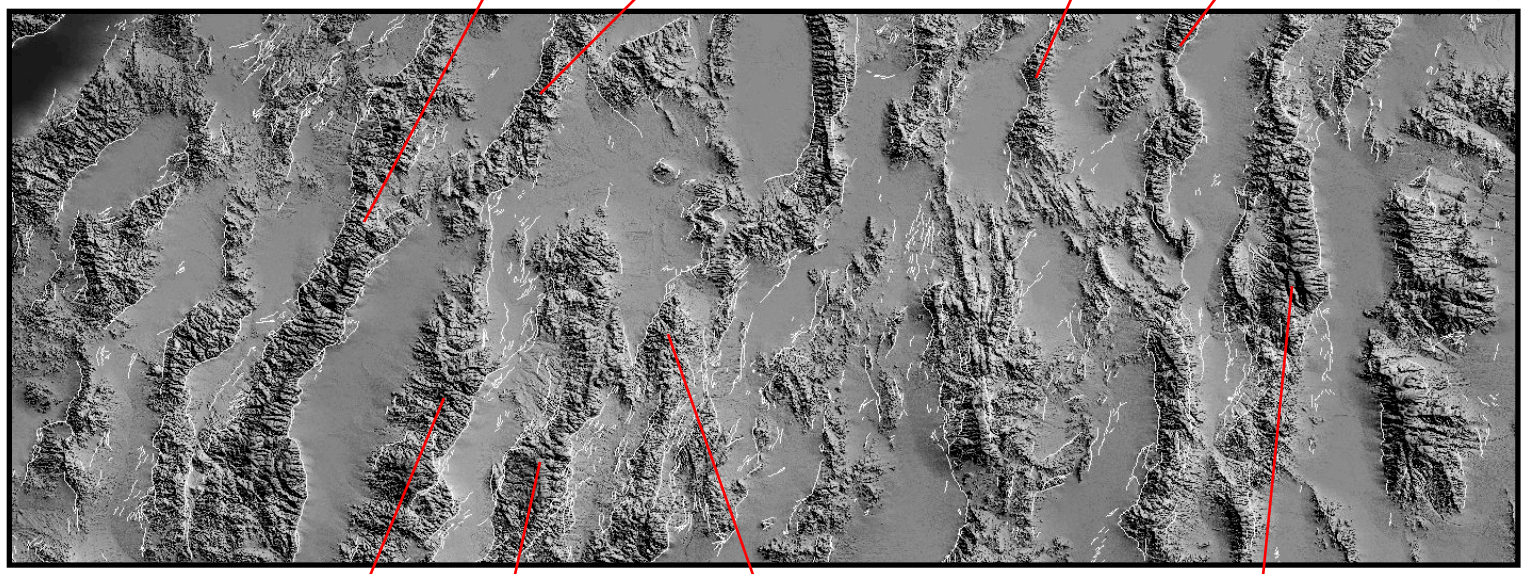
Outline of topics

- Basin and Range Province revisited
- Mapping normal faults in Nevada
- Assessing paleoseismic parameters from mapping observations

Mountain and basin topography is the result of Progressive extension and normal fault displacements

Fault mapping across US HWY 50 central Basin and Range





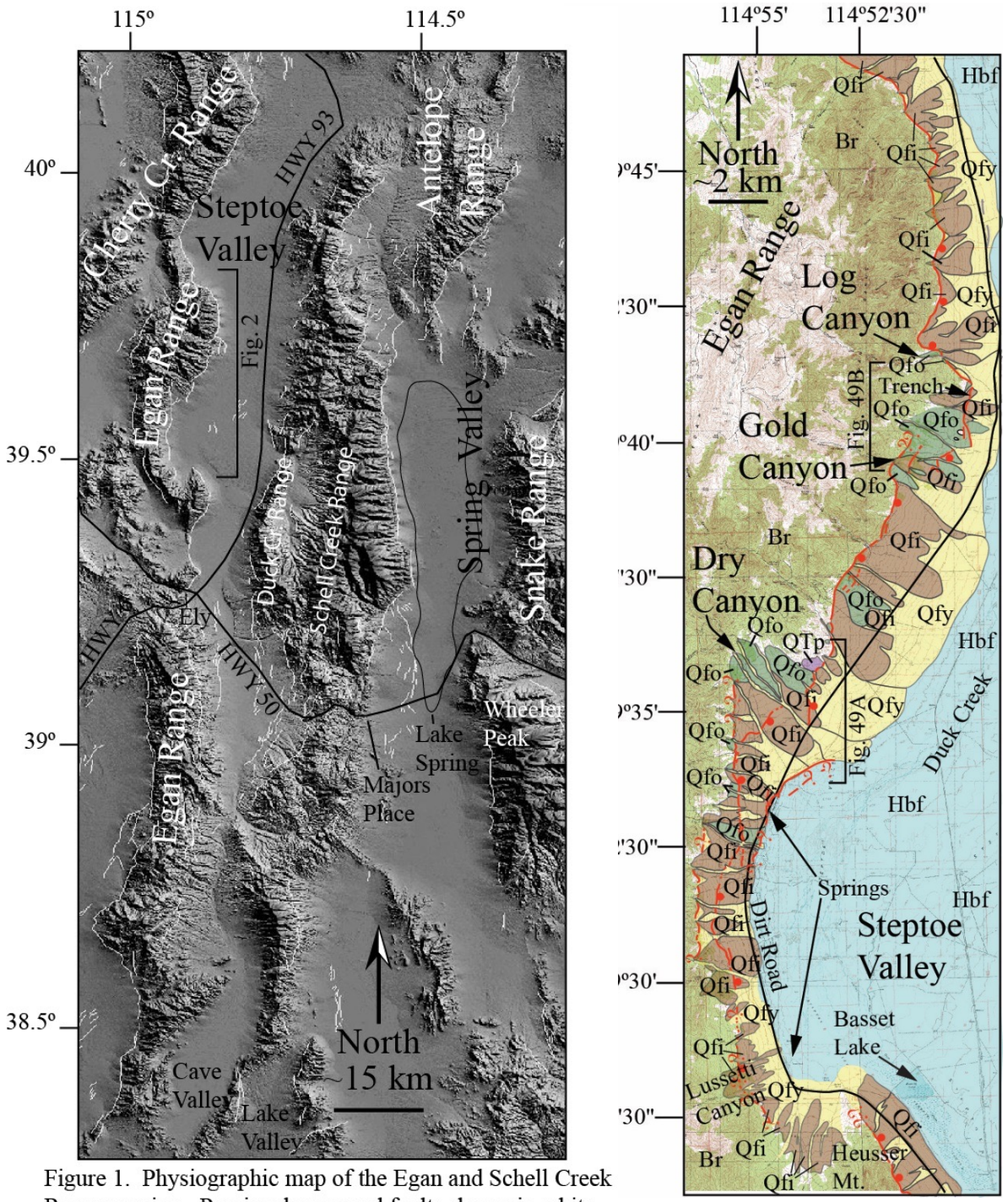
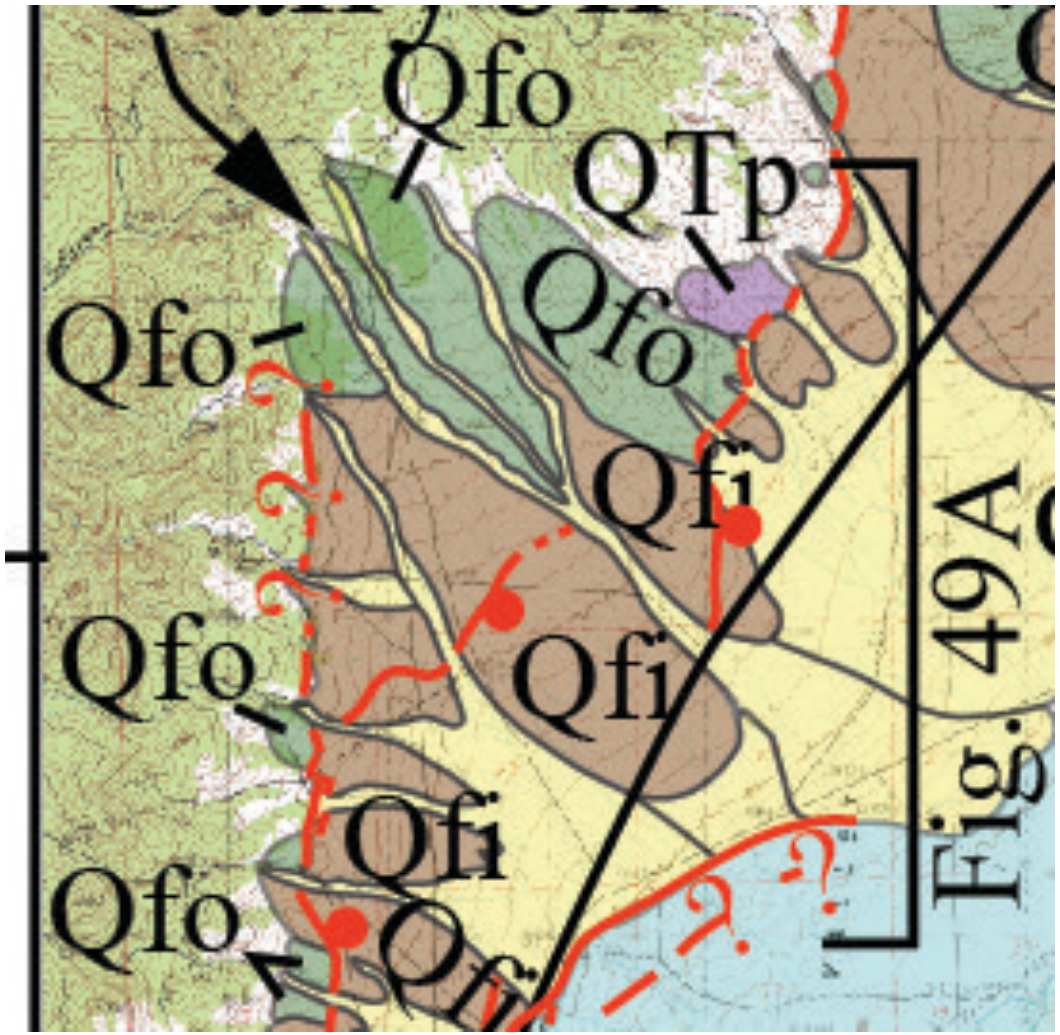
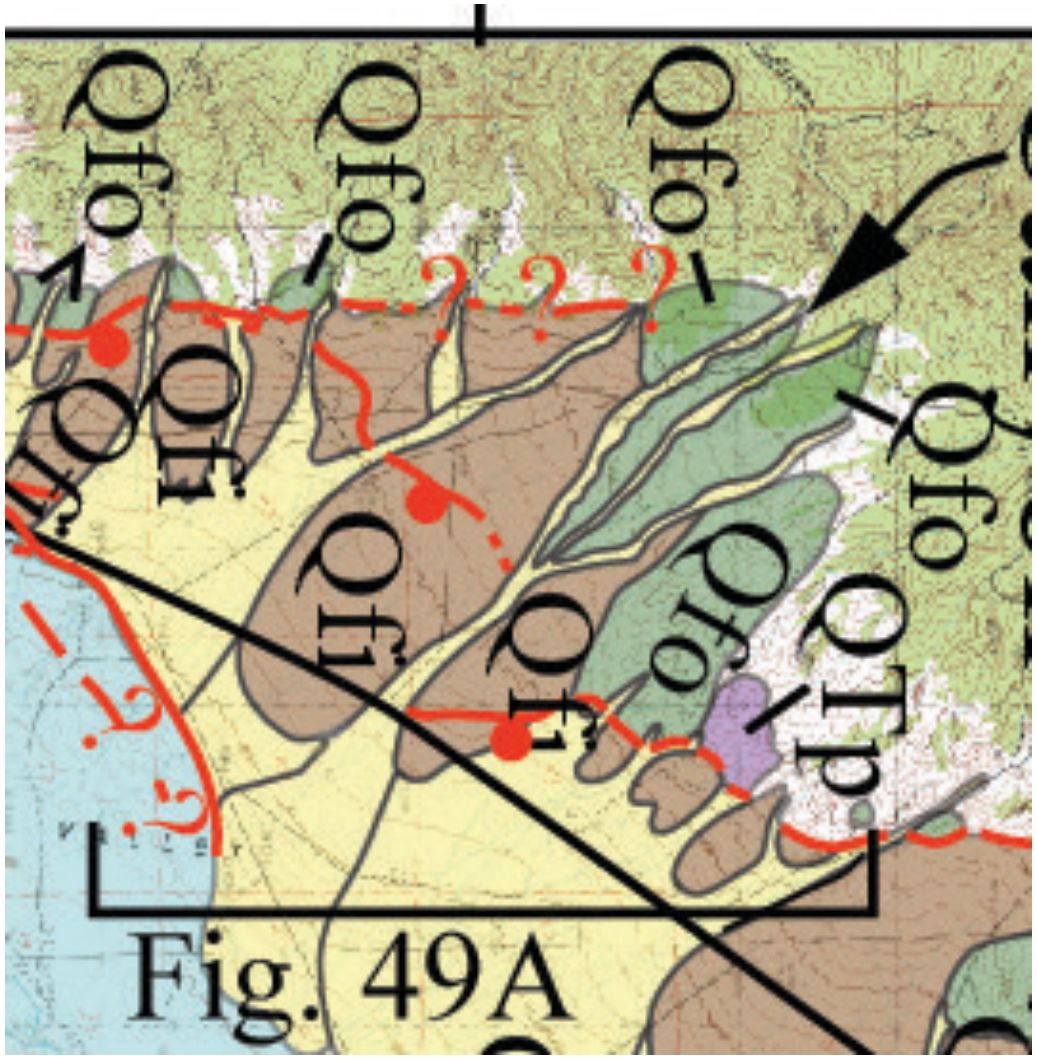


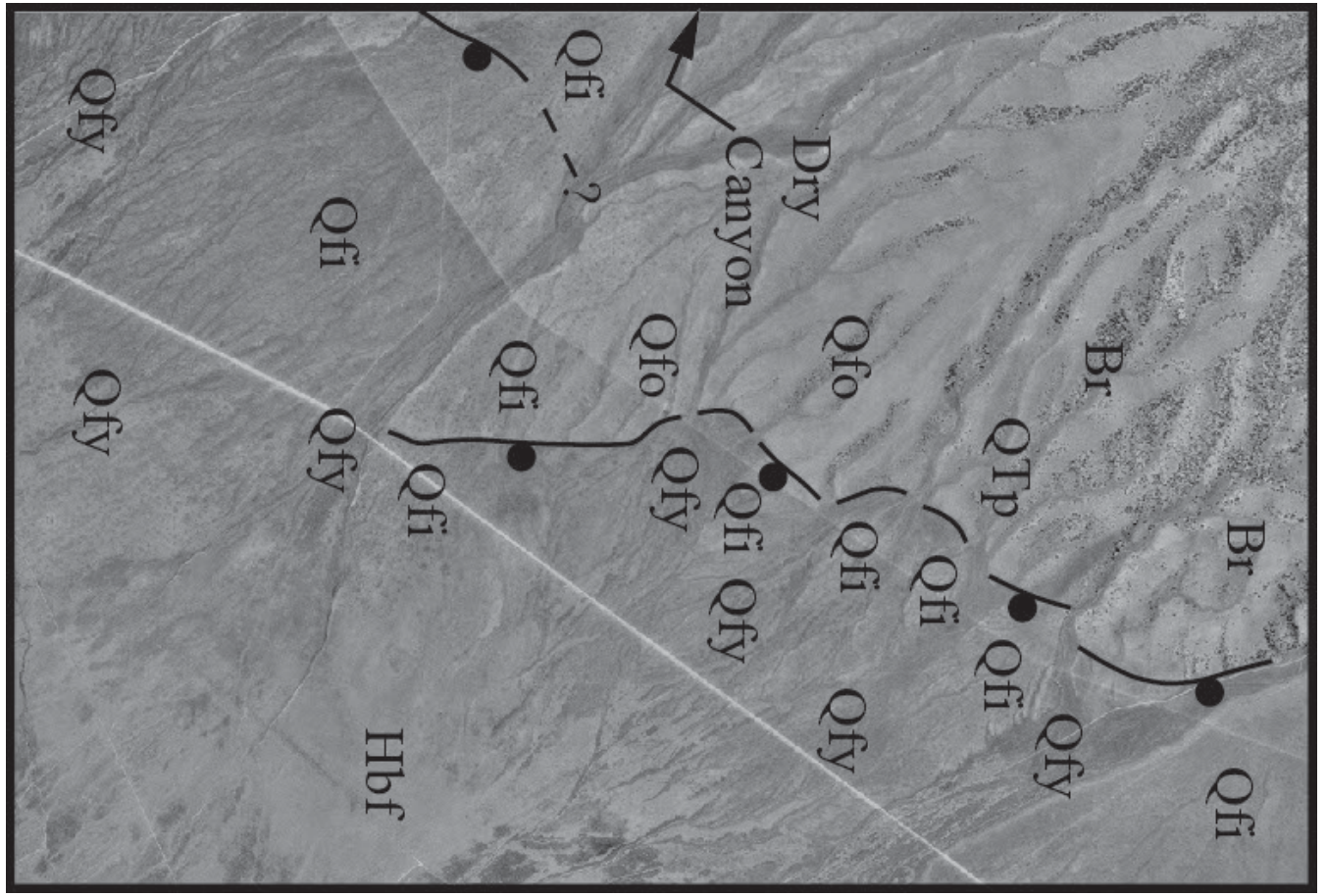
Figure 1. Physiographic map of the Egan and Schell Creek Ranges region. Previously mapped faults shown in white

Eagan Range

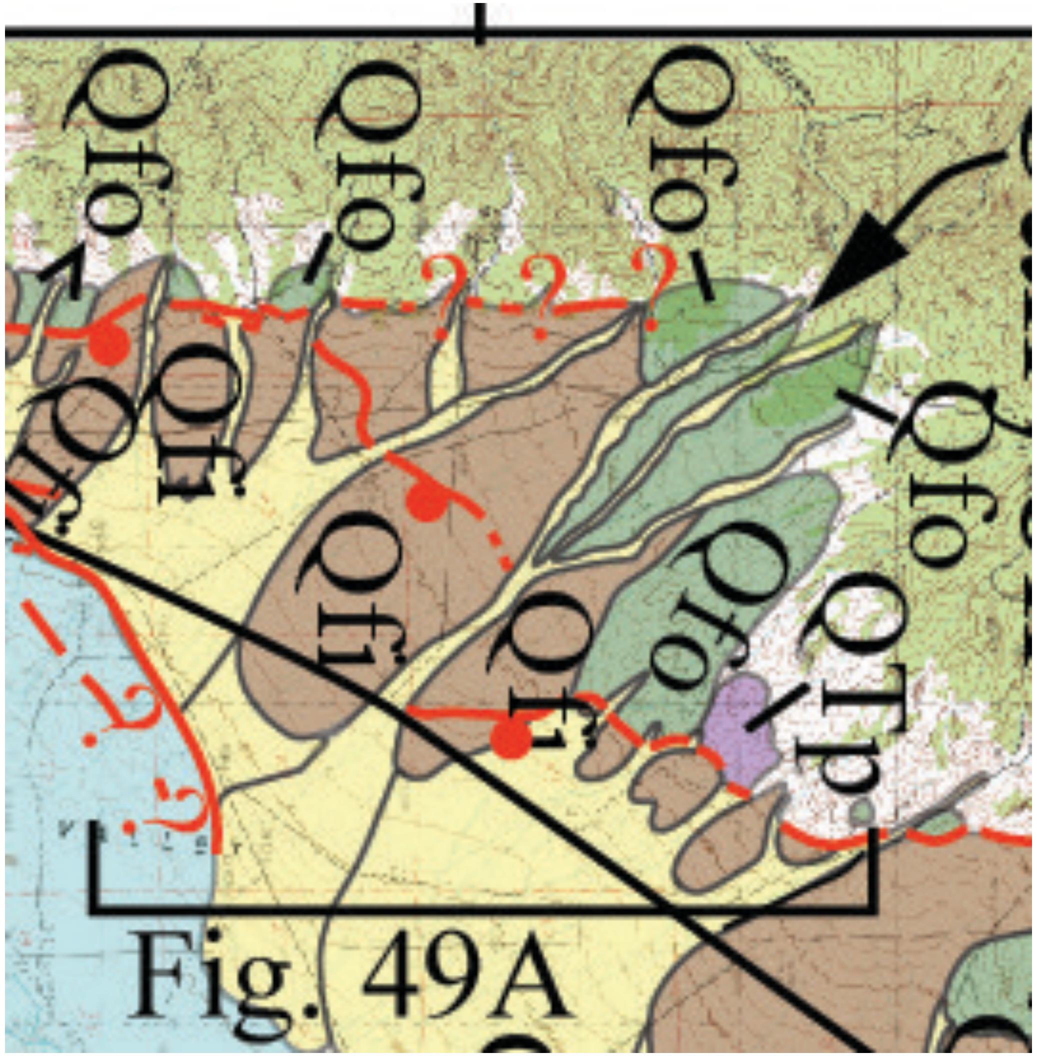


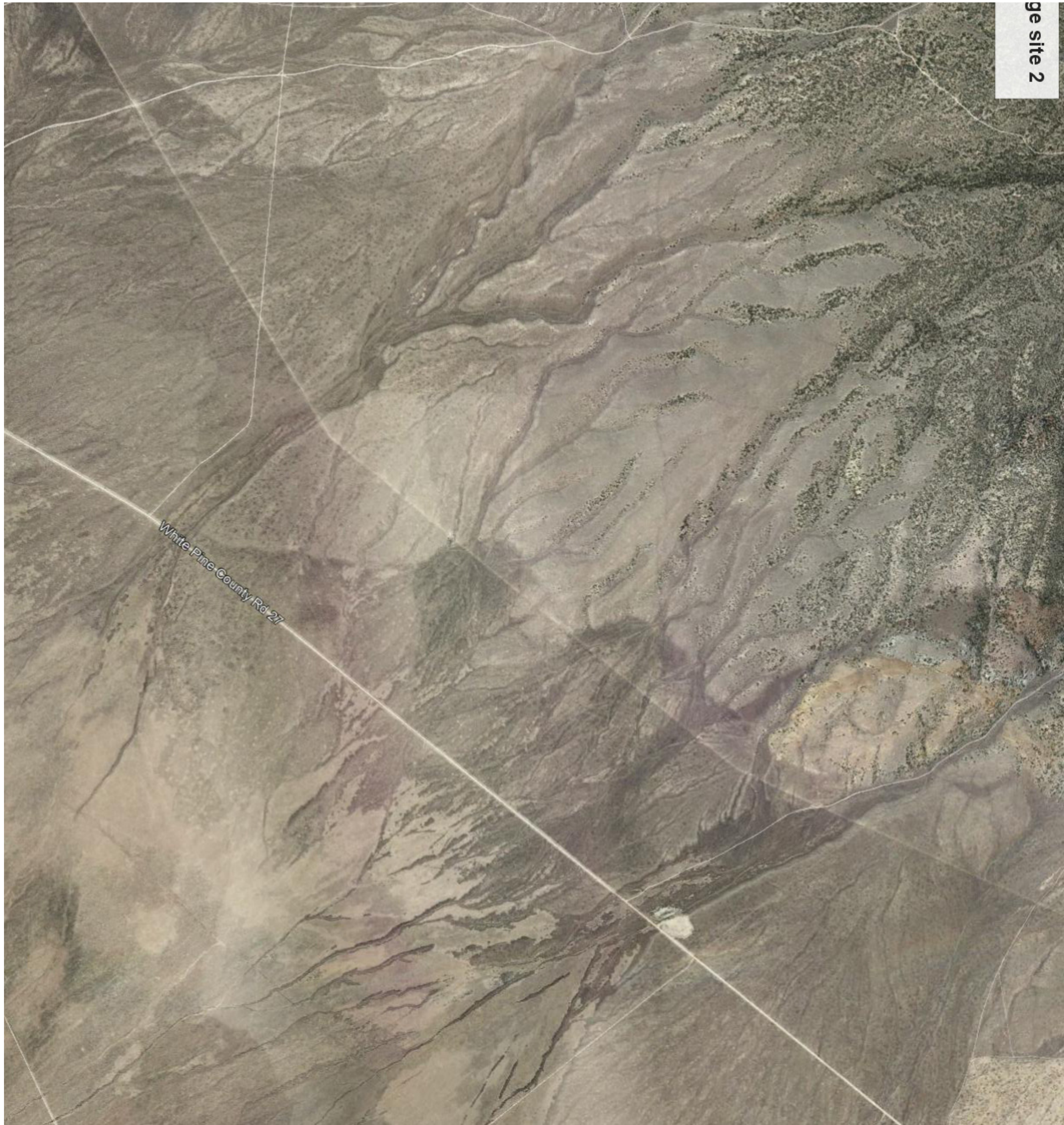
Eagan Range (cont.)



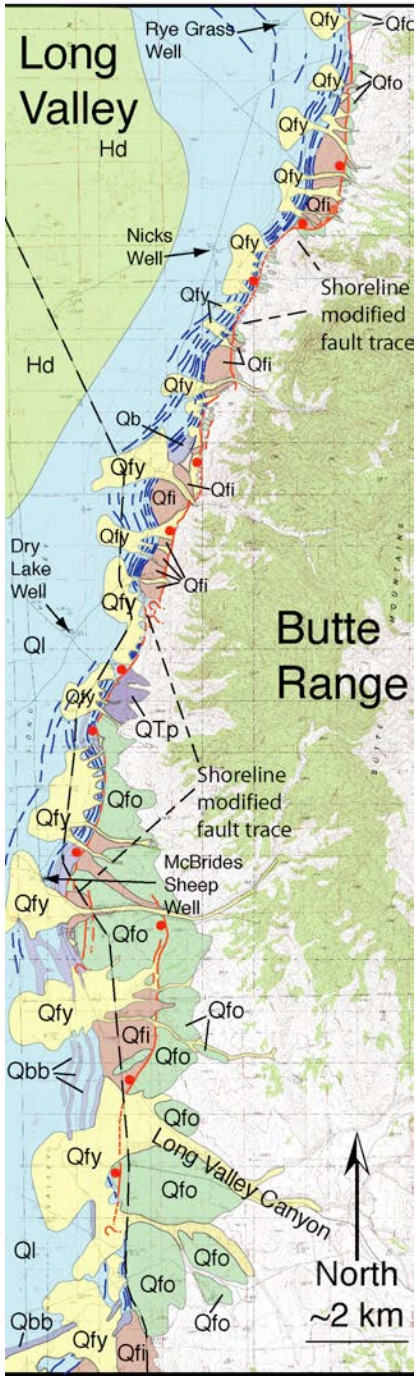


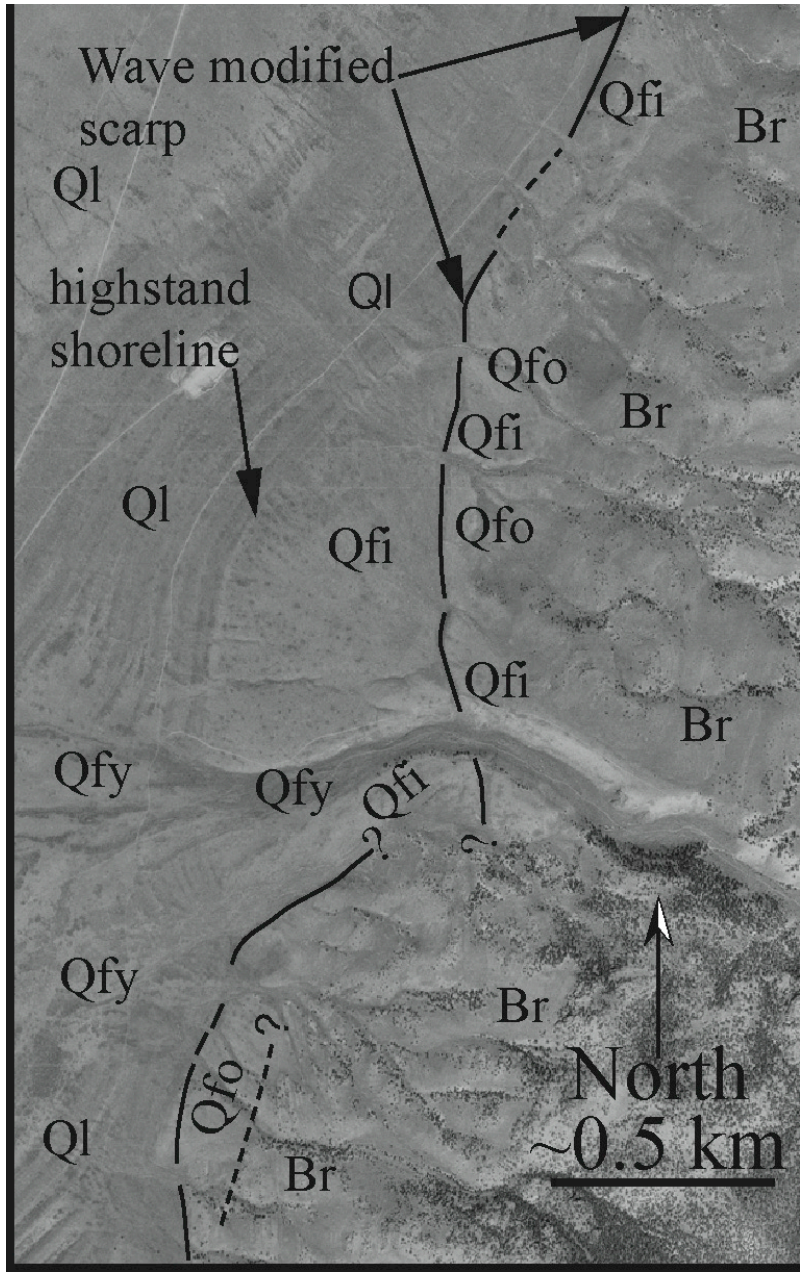
Eagan Range (cont.)

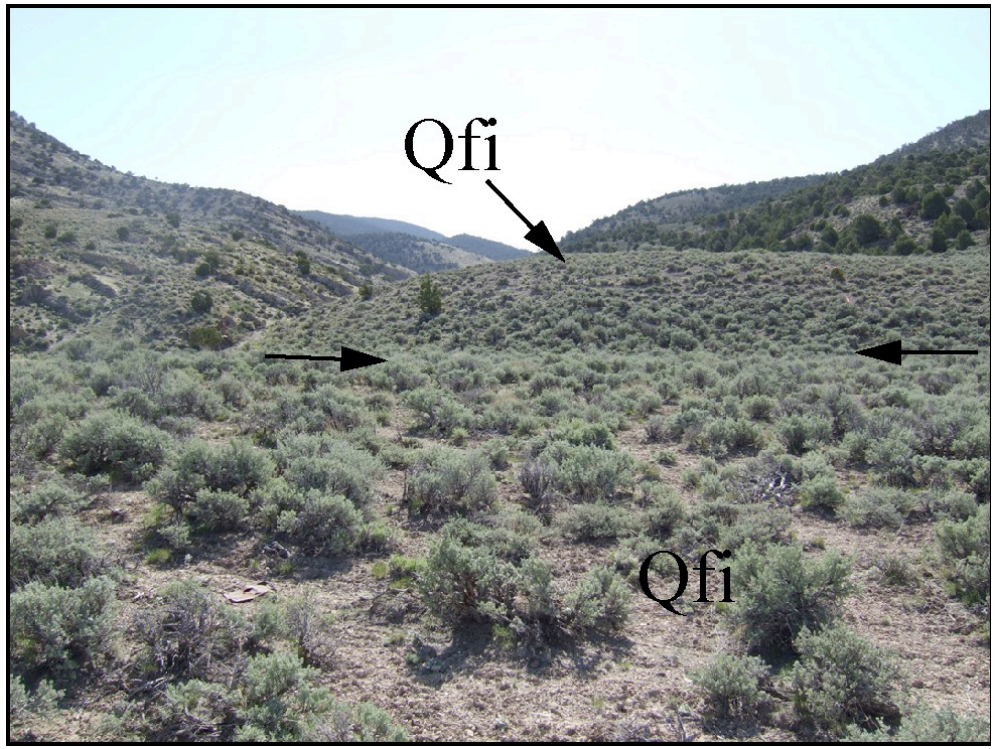




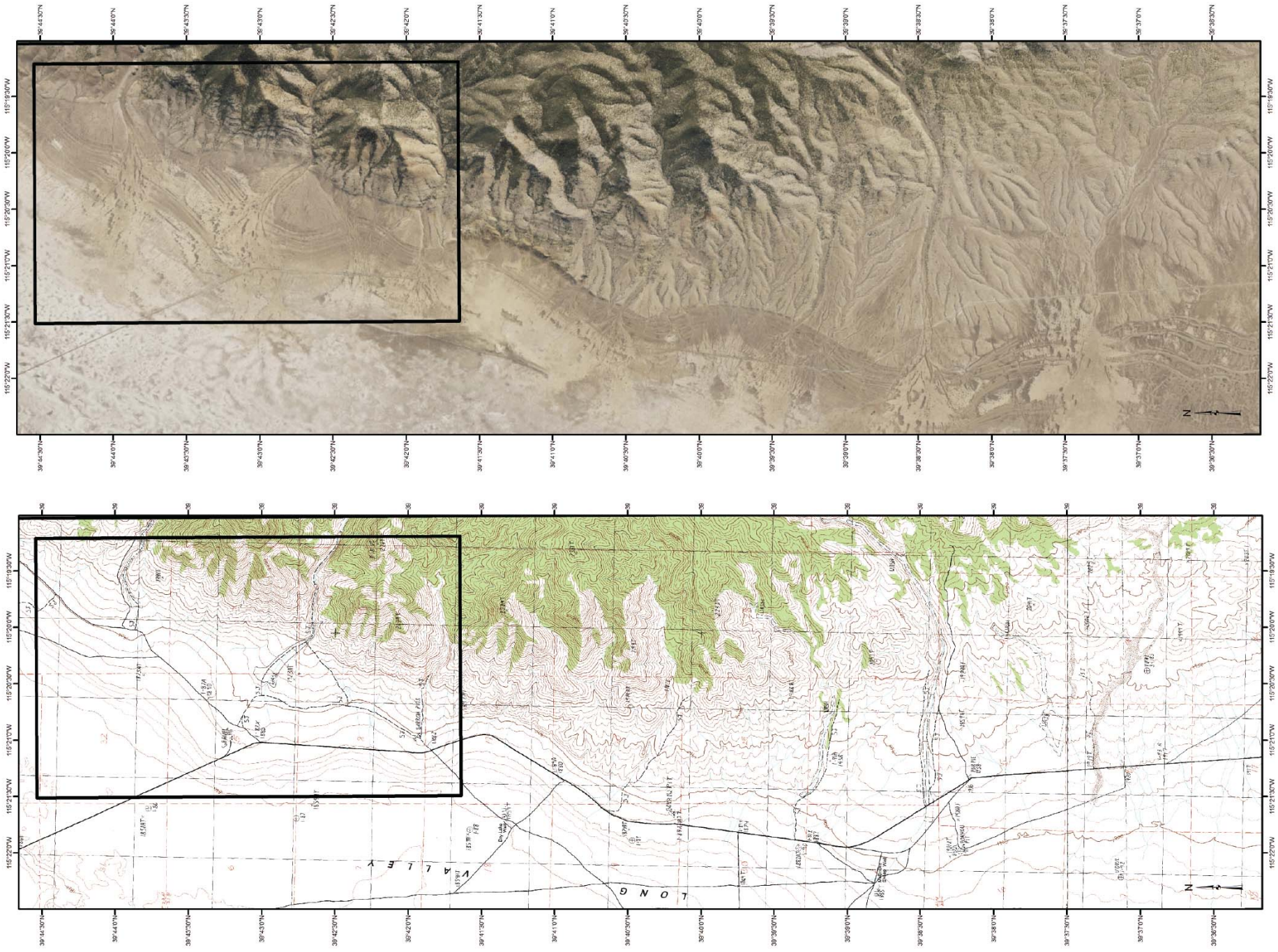
Butte Range


Long Valley
Hd
Rye Grass Well
Nicks Well
Shoreline modified fault trace
Dry Lake Well
Ql
Butte Range
QTp
Shoreline modified fault trace
McBrides Sheep Well
Qbb
Long Valley Canyon
North
~2 km
Qfy
Qfo
Qfi
Qb

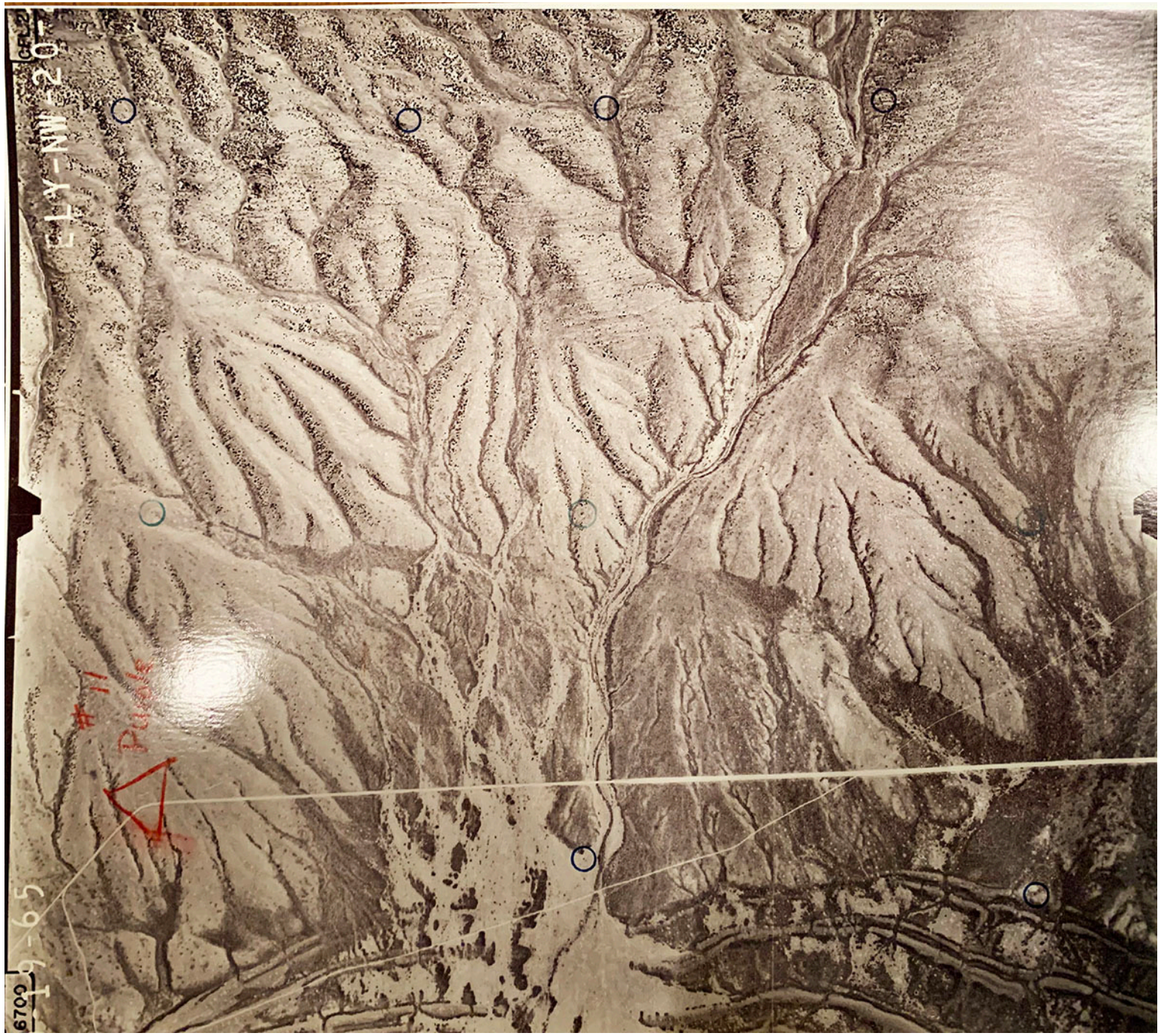

Wave modified scarp
highstand shoreline
Ql
Qfi
Qfo
Br
Qfy
North
~0.5 km


Qfi
Qfi

Butte Range (cont.)



Butte Range
(cont.)



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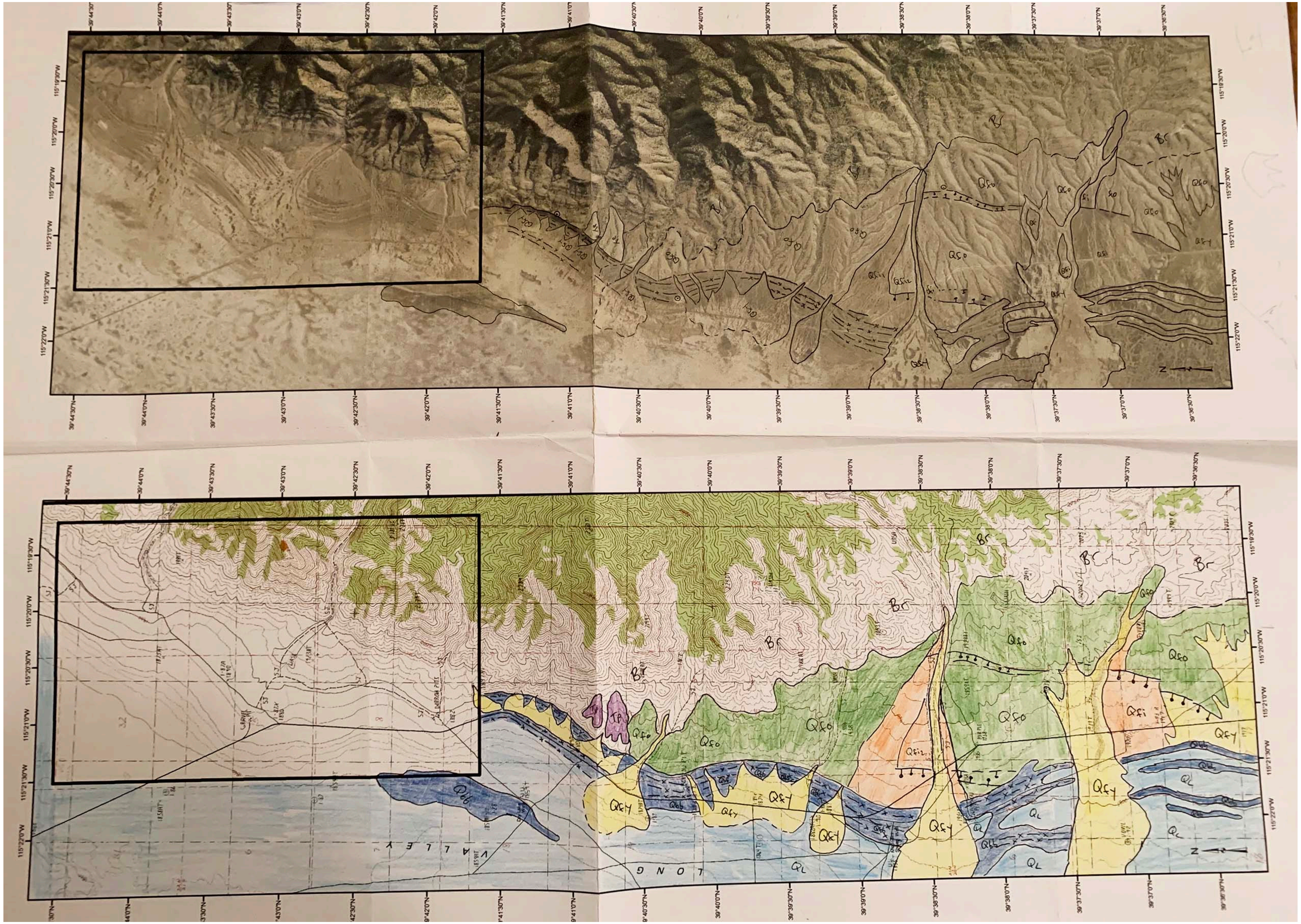
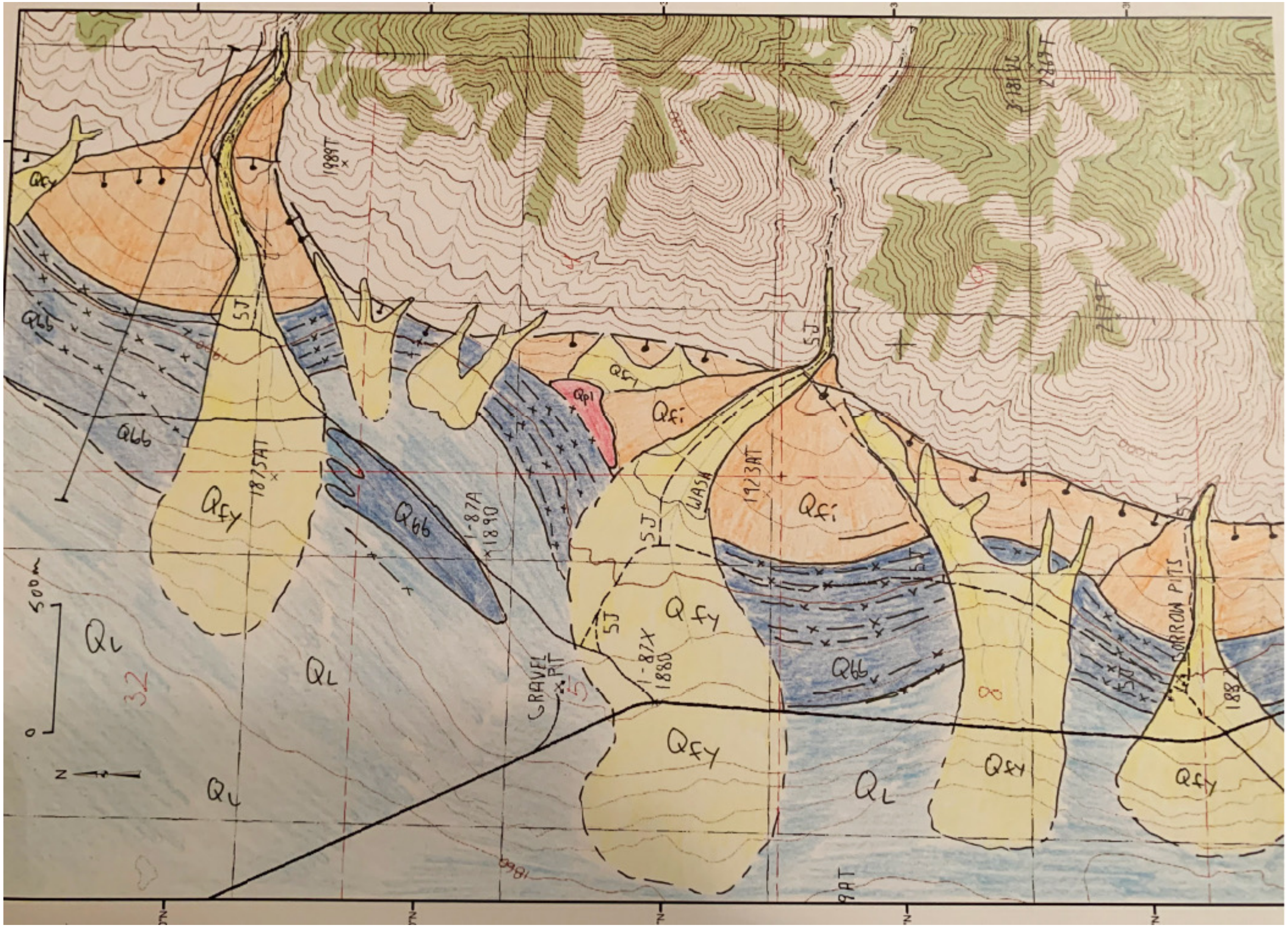
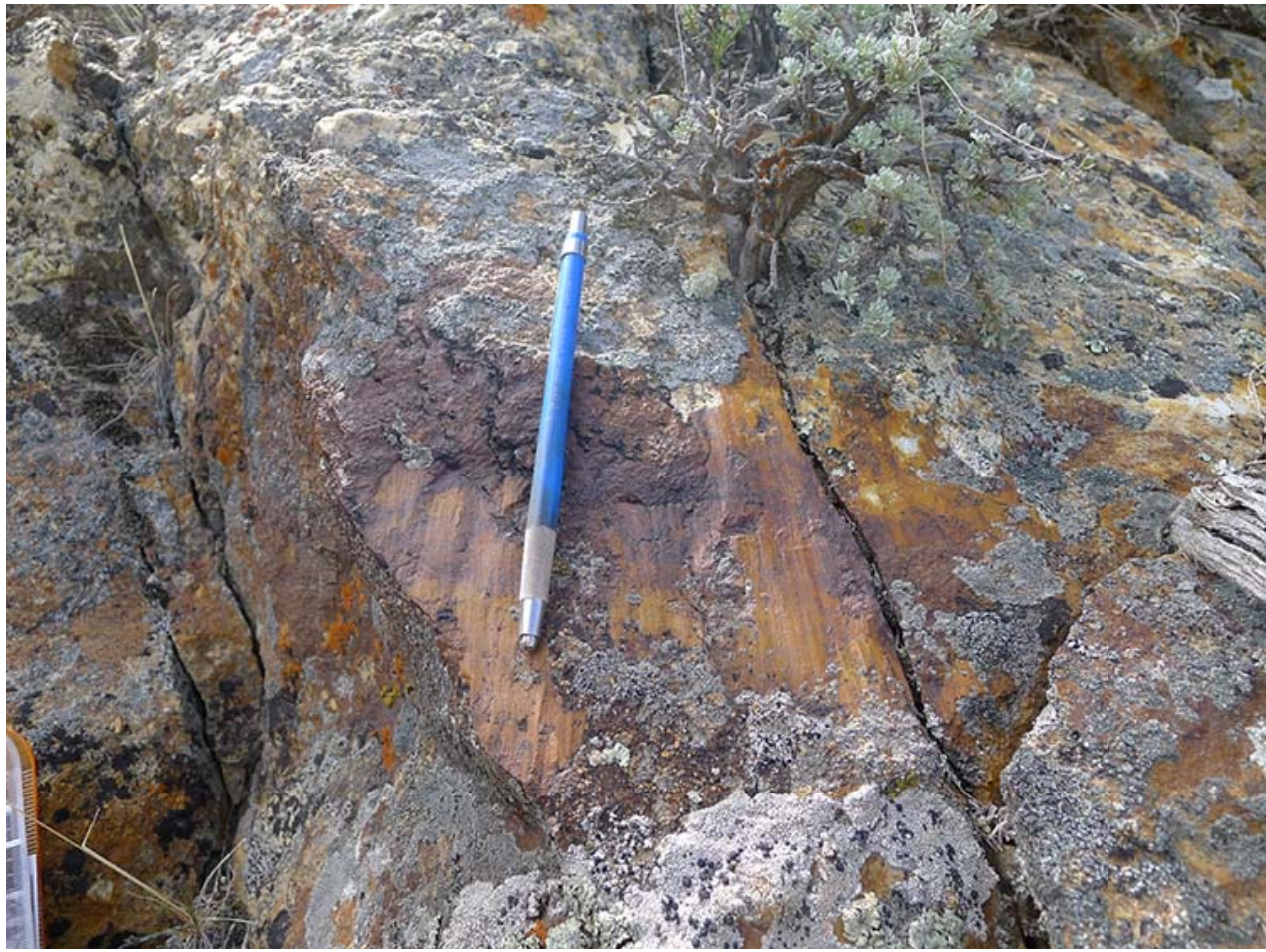
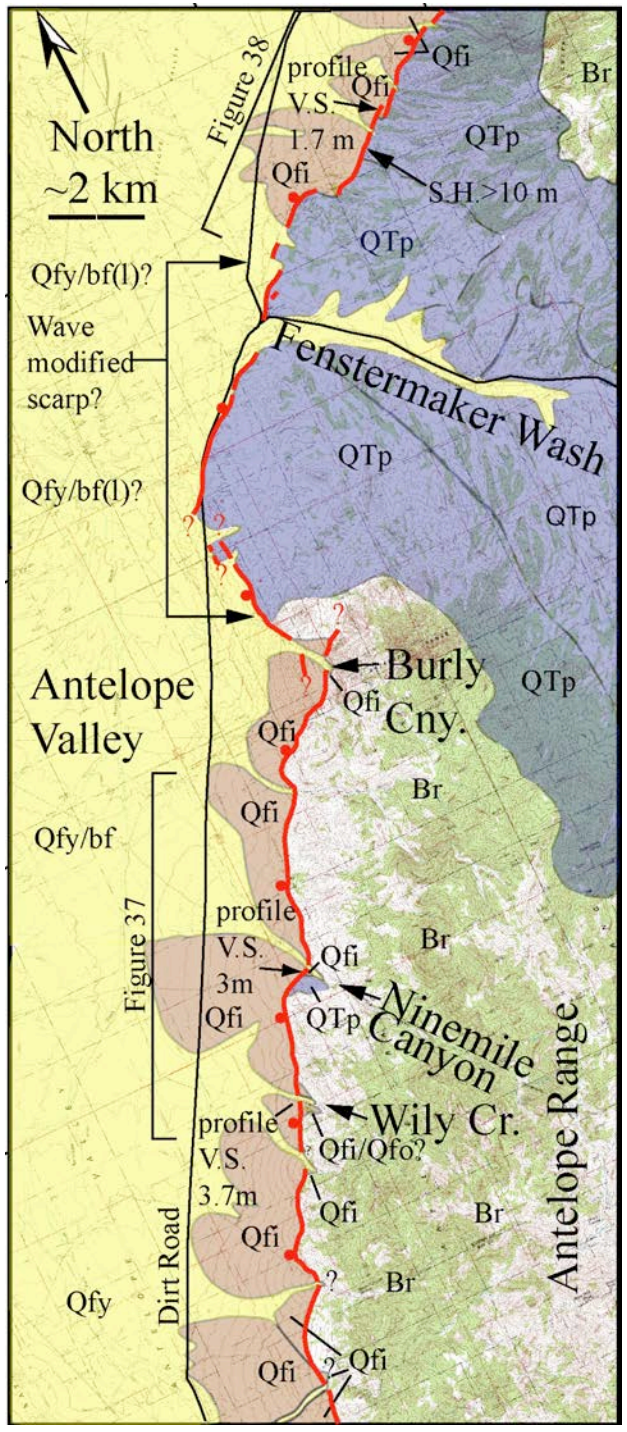


Butte Range (cont.)

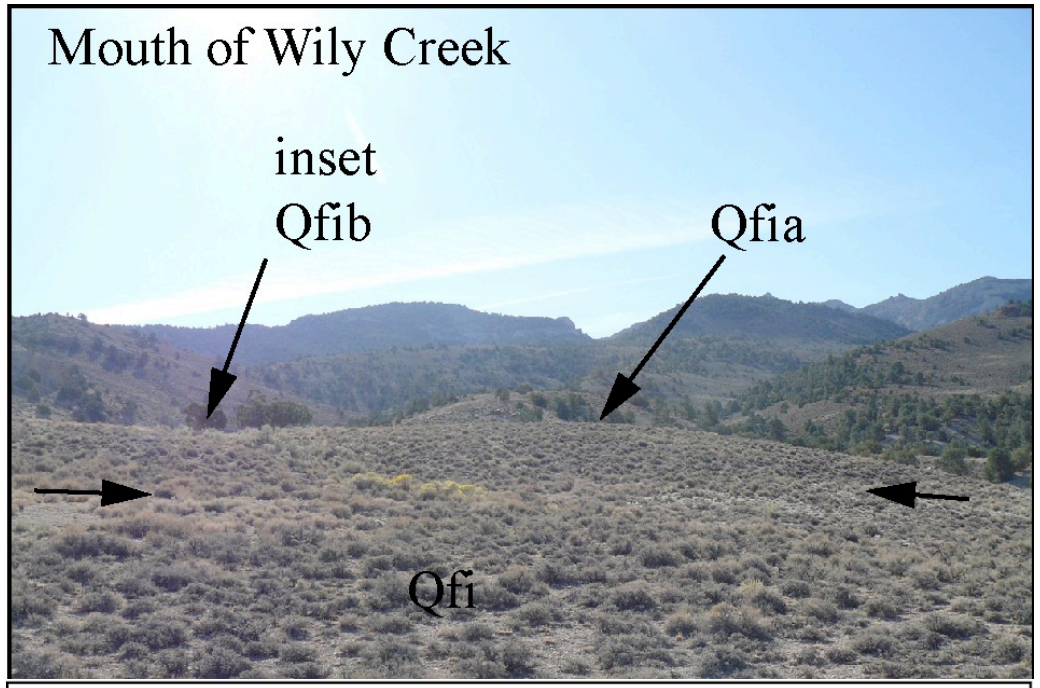
Butte Range (cont.)

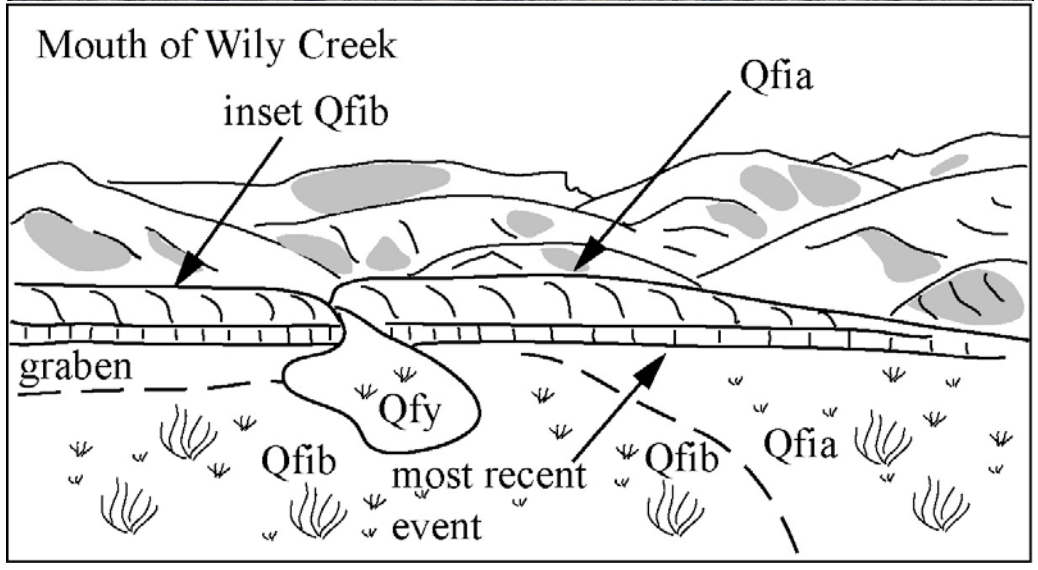






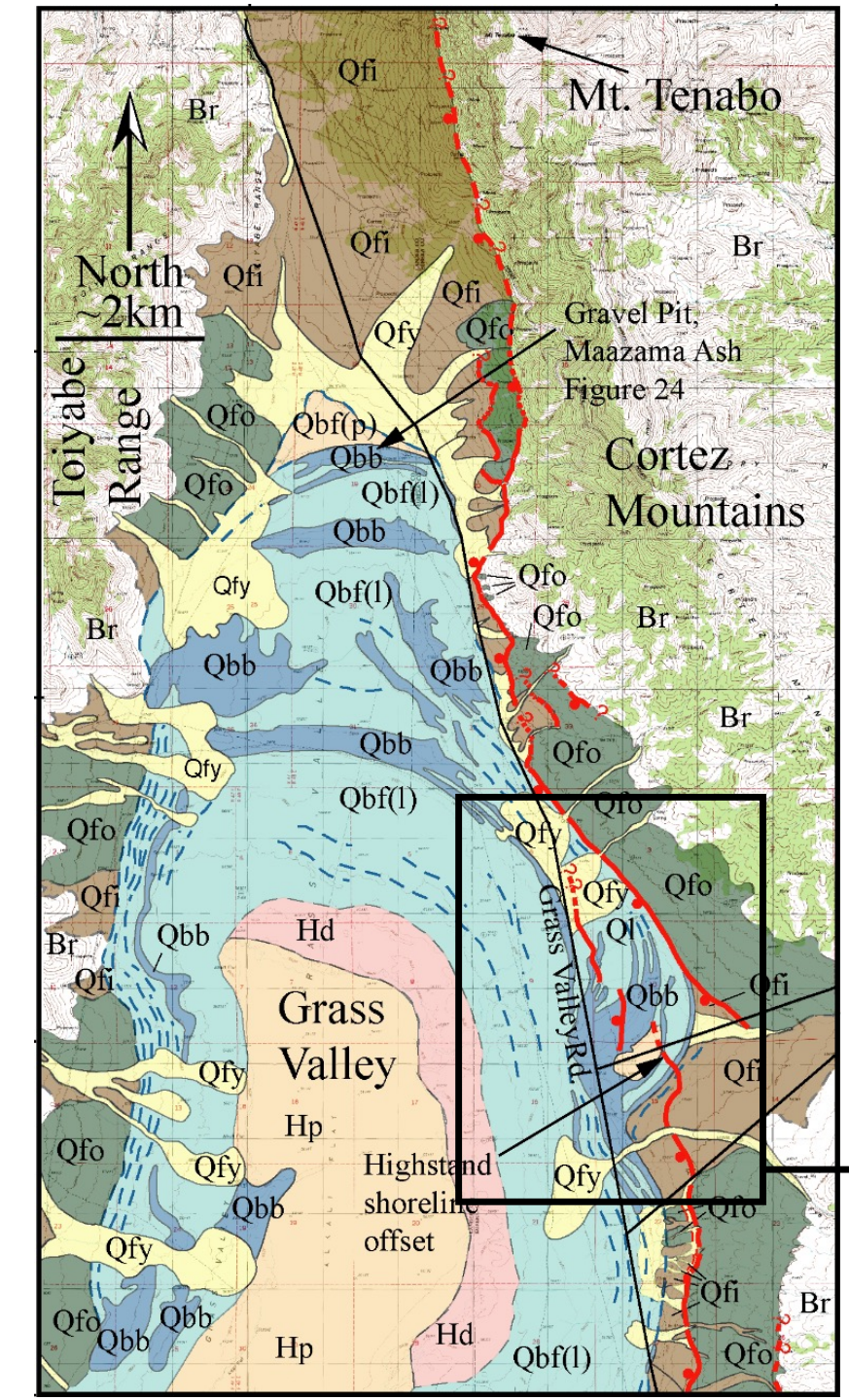
Antelope Range

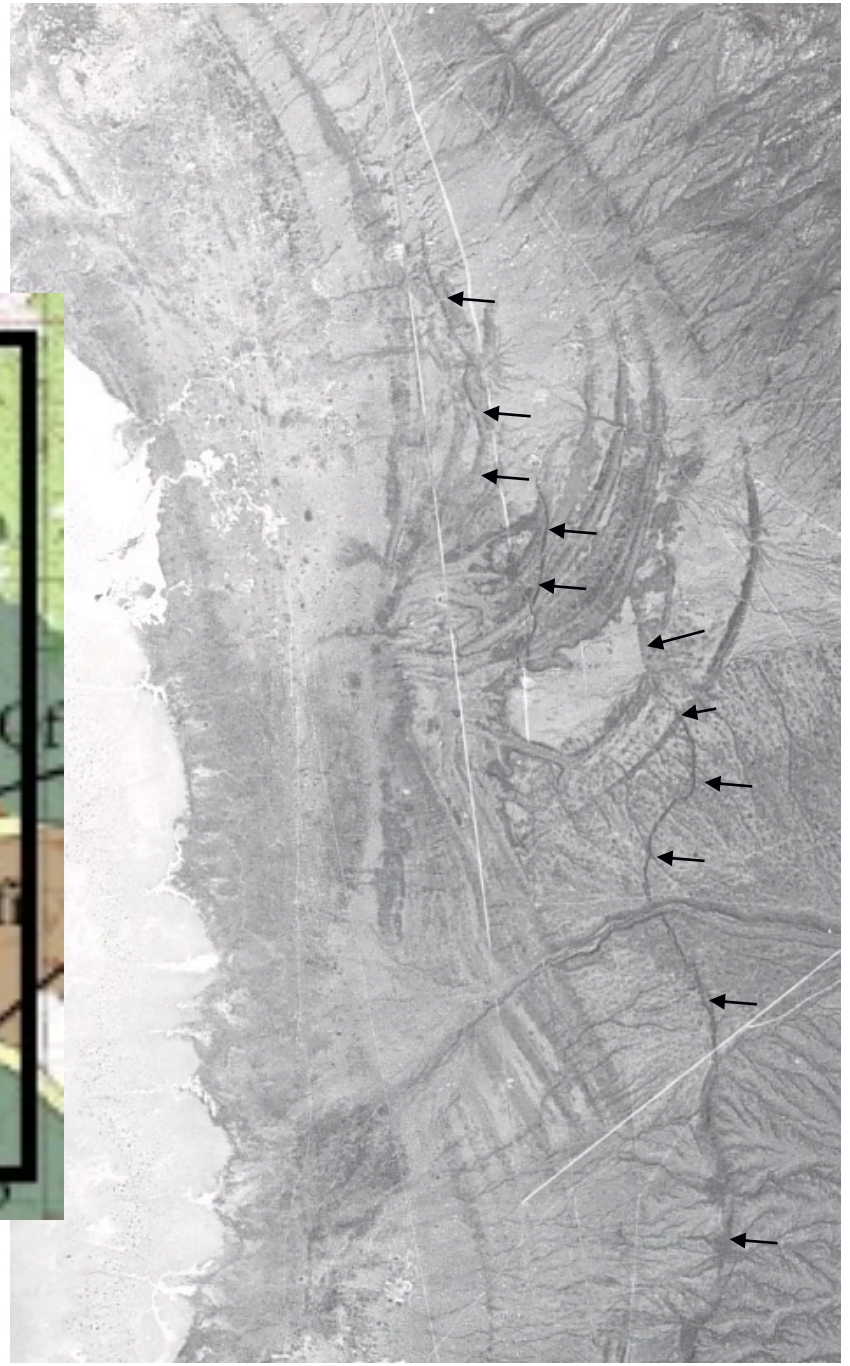




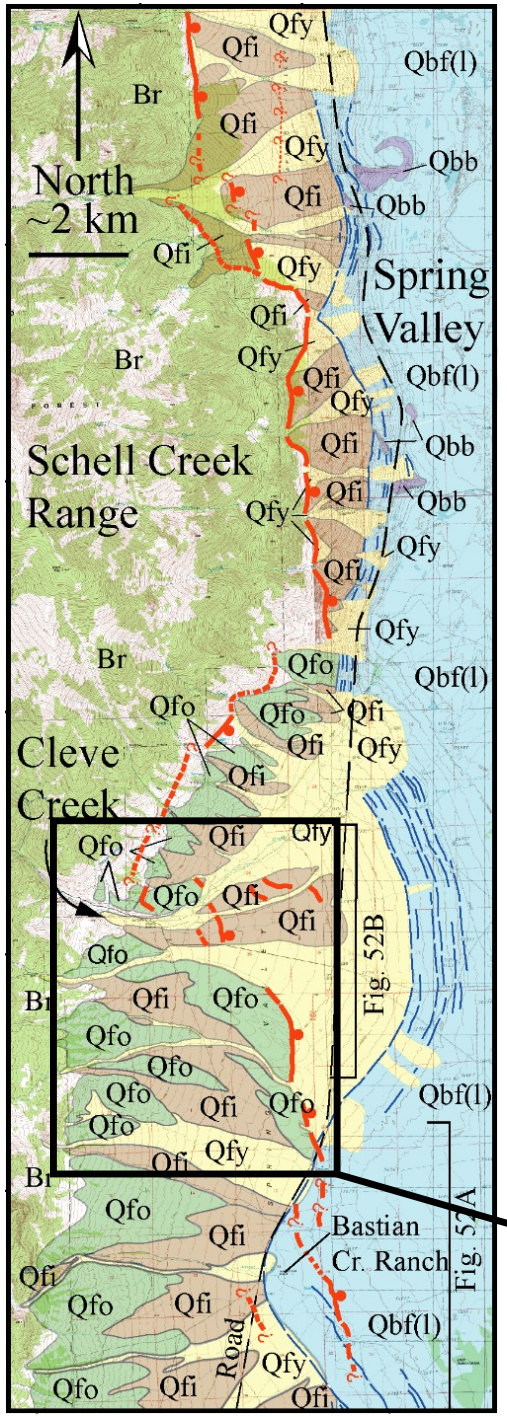
3 events recorded in scarp.

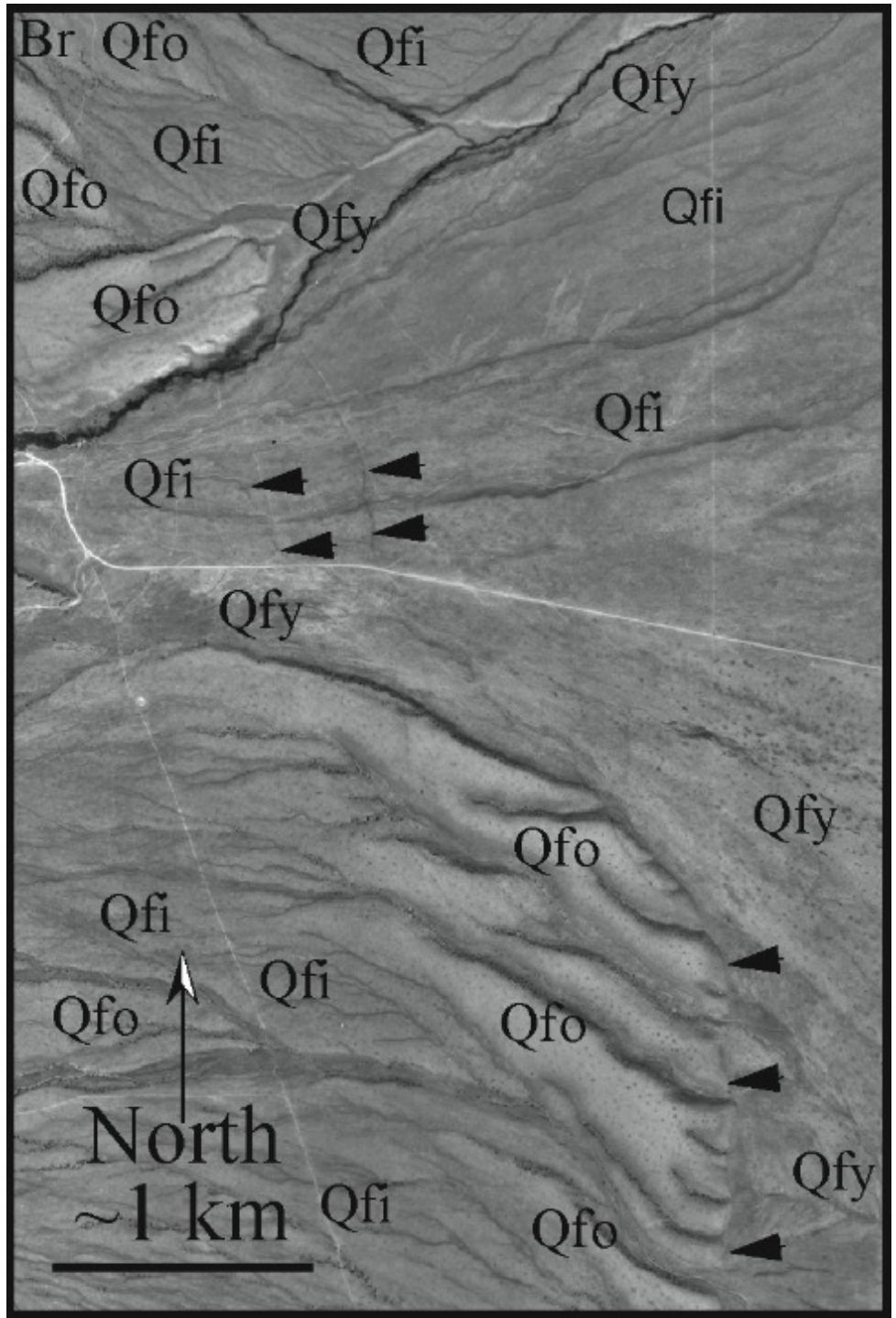
Simpson Park Range



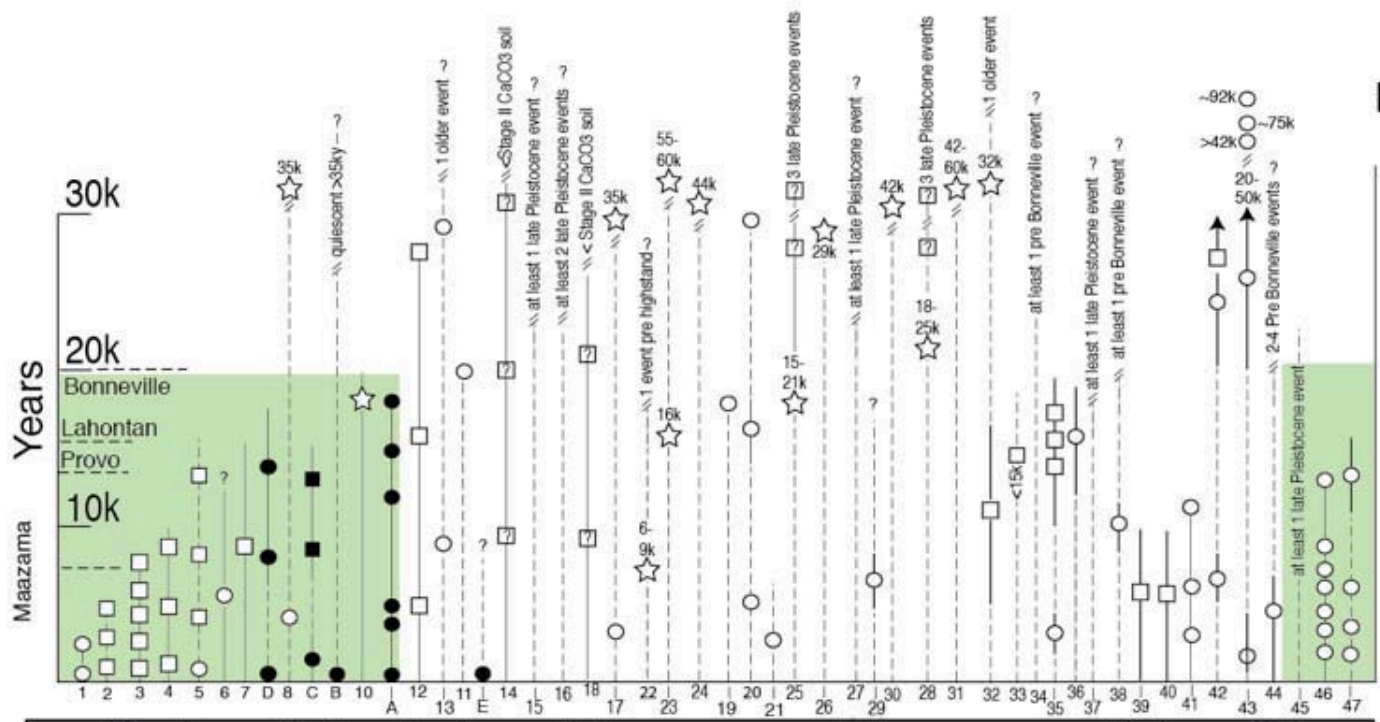


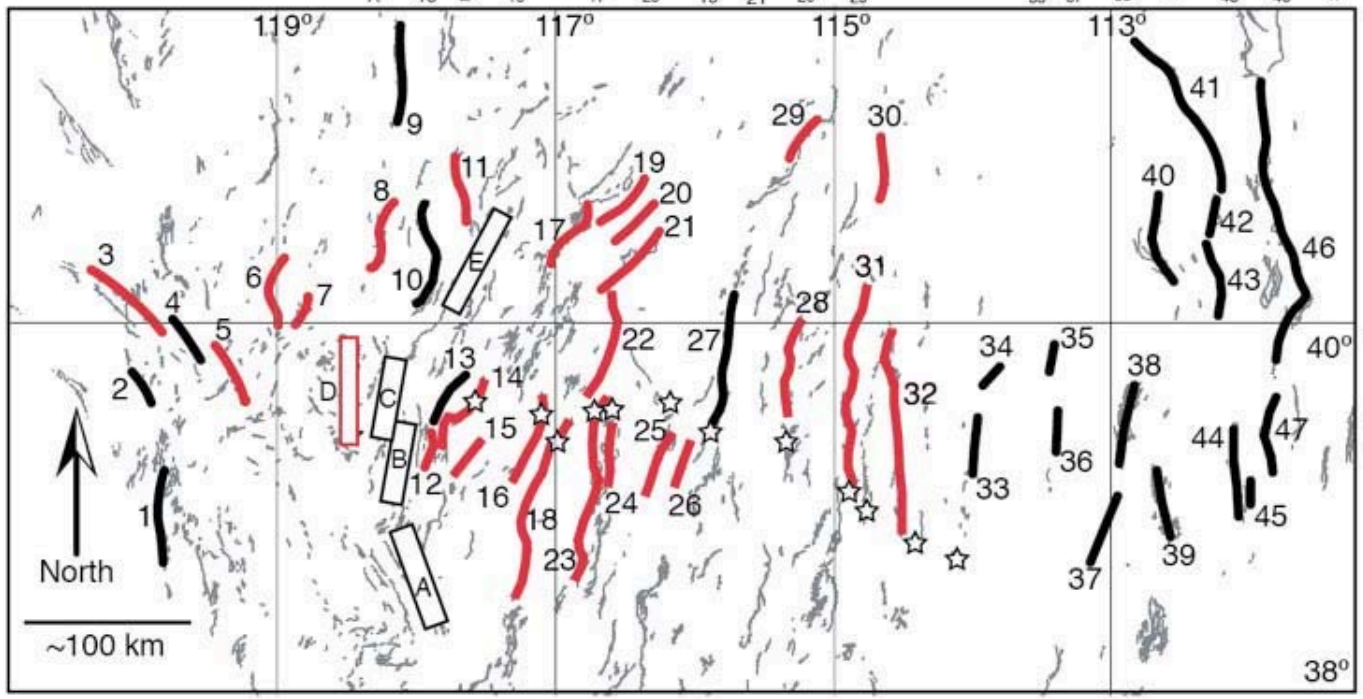
Schell Creek Range





SPACE-TIME PLOT OF EARTHQUAKE RECURRENCE

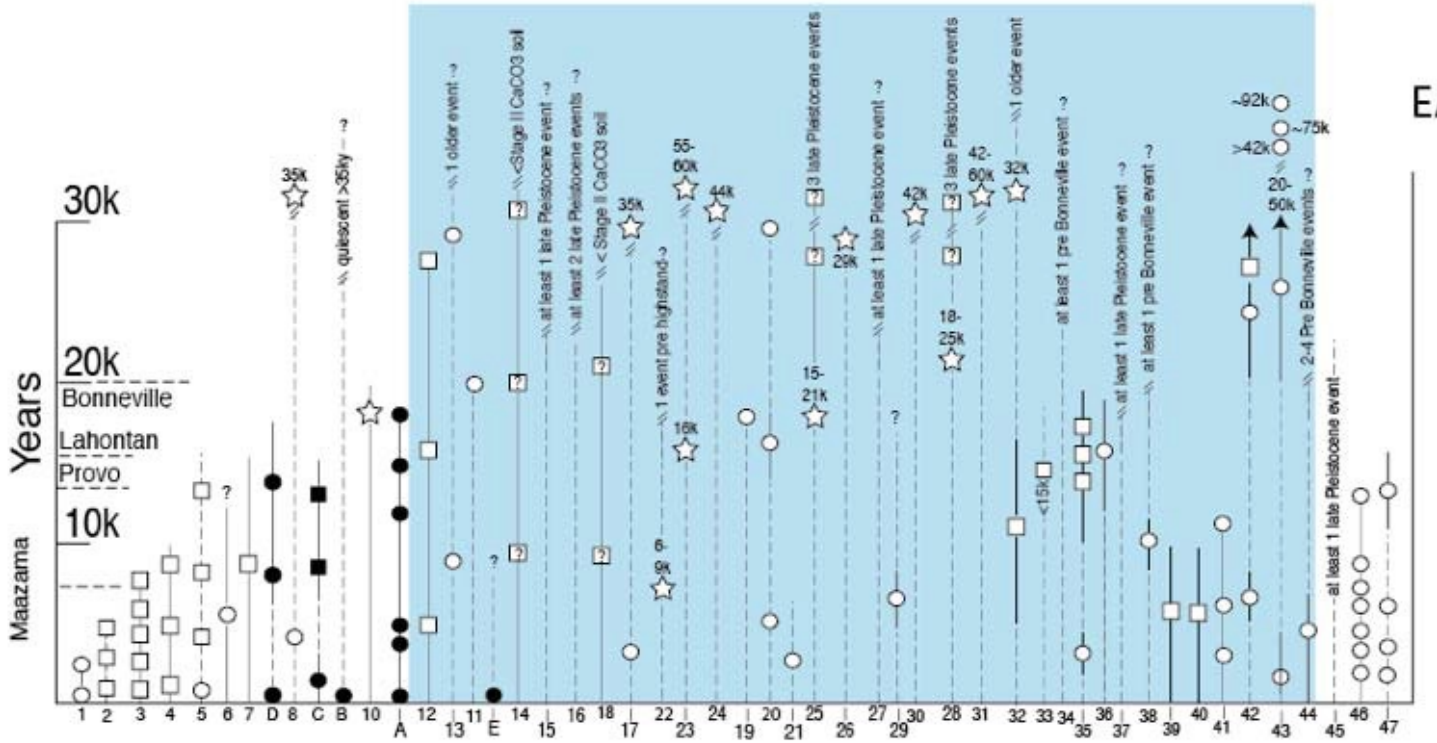




- DATED EARTHQUAKES
- EARTHQUAKES SINCE PARTICULAR TIME
- SCARP DIFFUSION ANALYSIS
- CENTRAL NEVADA SEISMIC BELT

- Center for Neotectonic Studies
- USGS, NBMG, UGS (Utah)
- Historical Ruptures of CNSB
- Pts Along Hwy 50

SPACE-TIME PLOT OF EARTHQUAKE RECURRENCE



- DATED EARTHQUAKES
- EARTHQUAKES SINCE PARTICULAR TIME
- SCARP DIFFUSION ANALYSIS
- CENTRAL NEVADA SEISMIC BELT

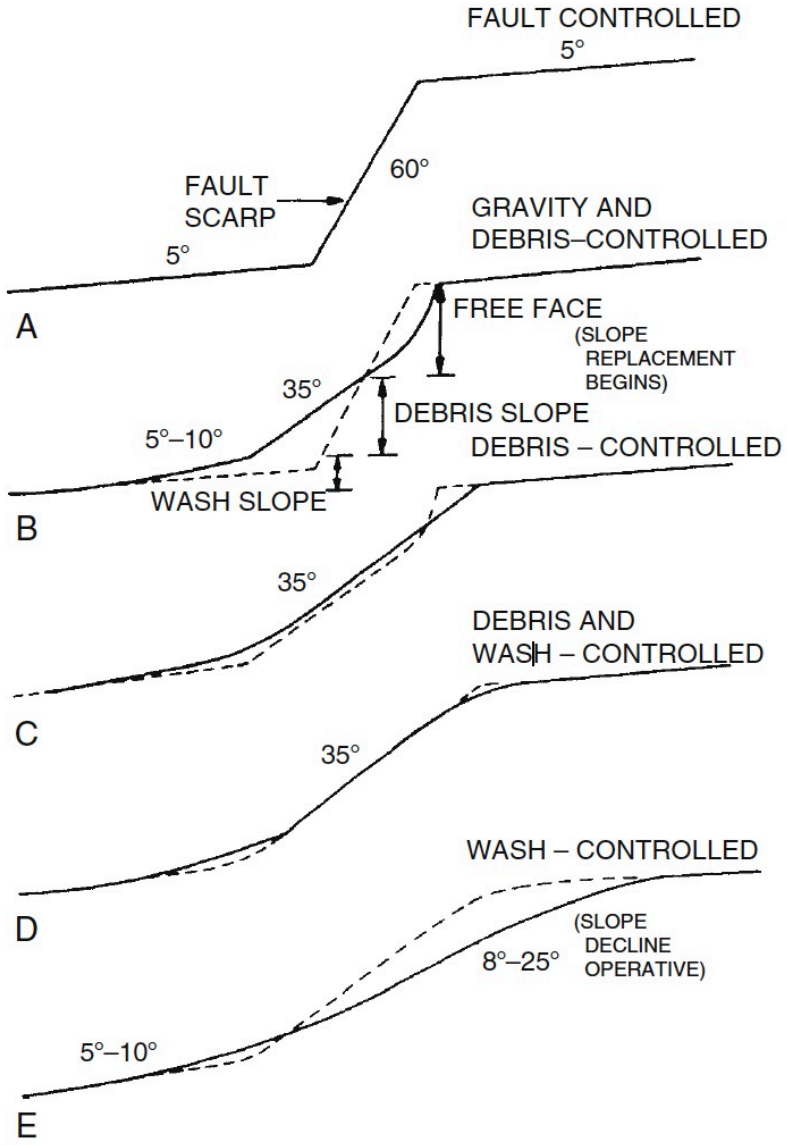
Fault	Vertical Separation (60 ky)	Extension	Strike	E-W Component of Extension
13. Clan Alpine	6 m	3.5 m	27°	3.1 m
.	.	.	.	.
.	.	.	.	.
SUM	91.3 m	58.5 m		48.4 m

48. 4 m / 60 ky = 0.8 mm/yr

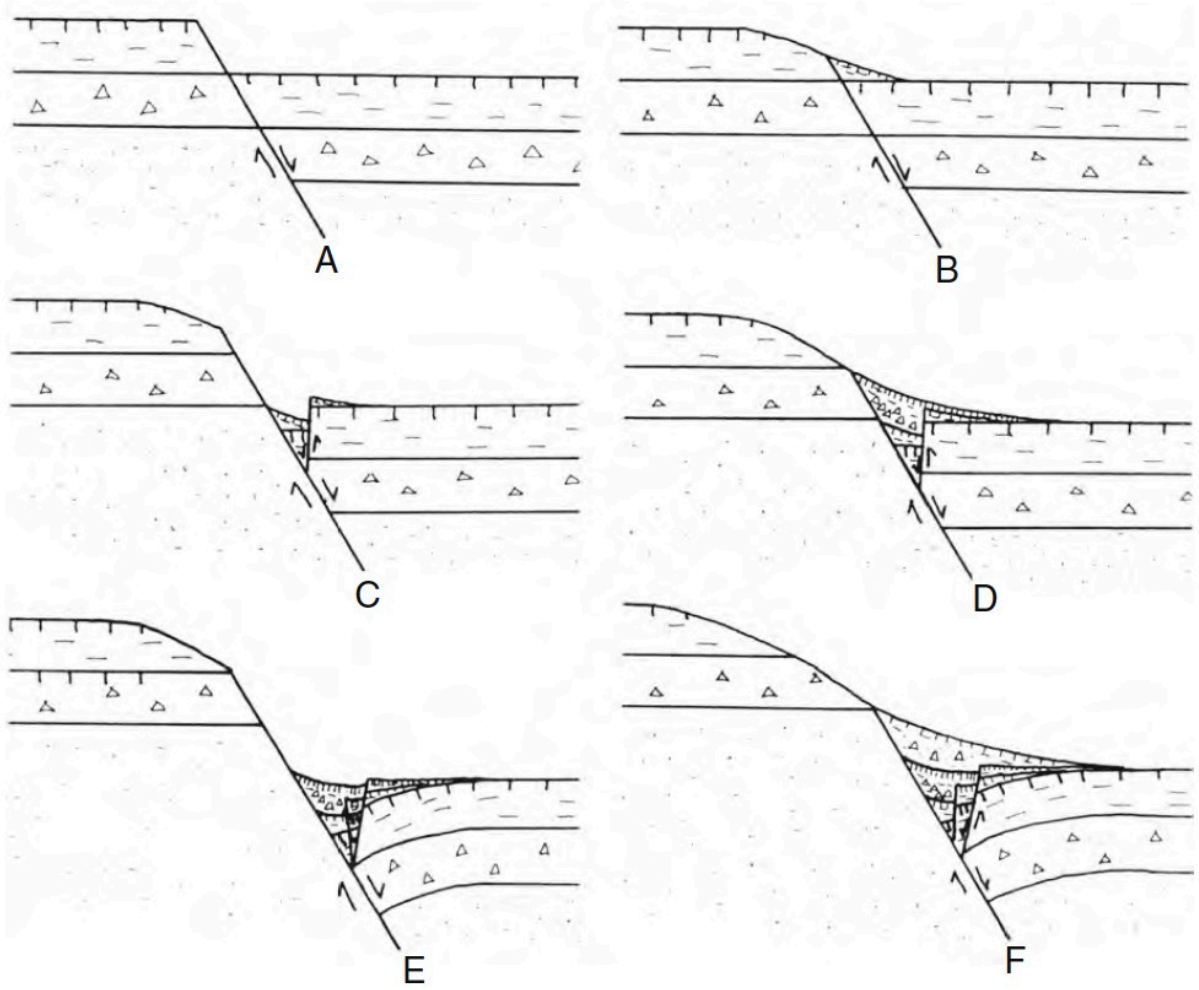
Fault	Vertical Separation (20 ky)	Extension	Strike	E-W Component of Extension
13. Clan Alpine	1.2 m	0.7 m	27°	0.6 m
.	.	.	.	.
.	.	.	.	.
SUM	35.4 m	24.5 m		19.3 m

19.3 m / 60 ky = 1.0 mm/yr

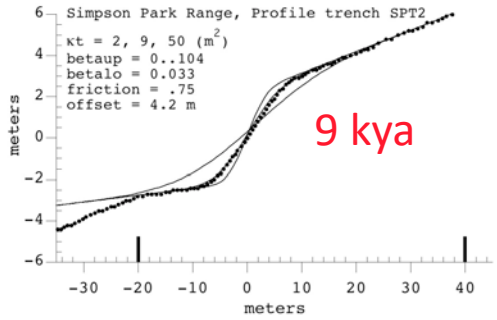
Colluvial facies related to scarp degradation



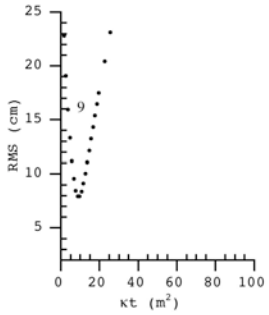
Subsurface colluvial stratigraphy



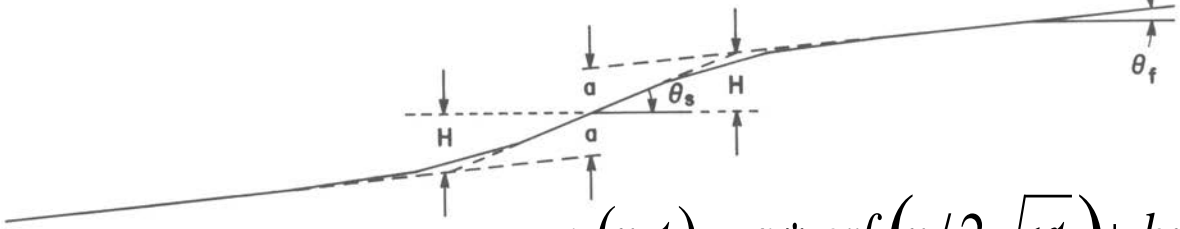
Diffusion Analyses of Scarp Profiles



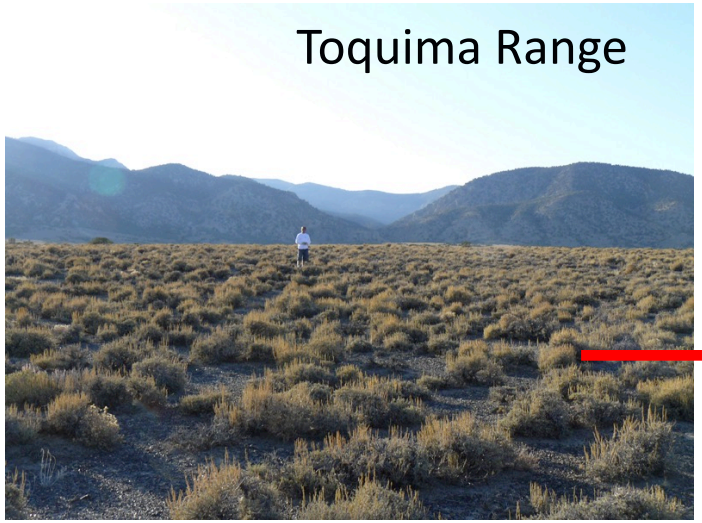
9 kya

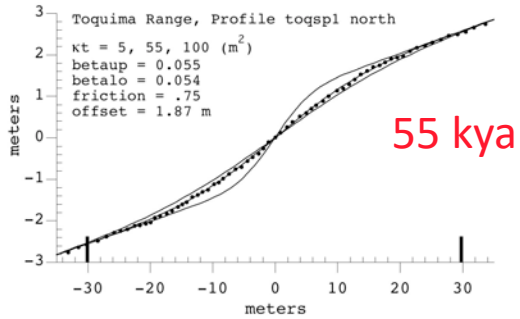


$$u(x,t) = du/dt - \kappa(d^2u/dx^2) = 0$$

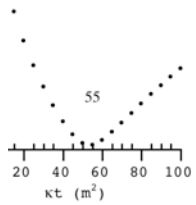


$$u(x,t) = a * erf\left(x / 2\sqrt{\kappa t}\right) + bx$$





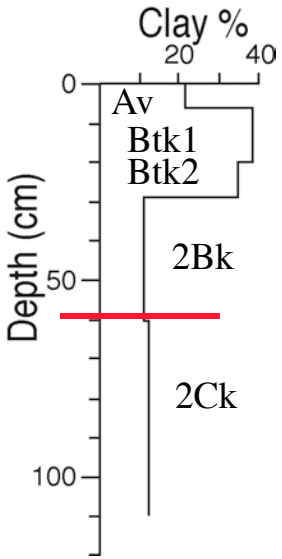
55 kya



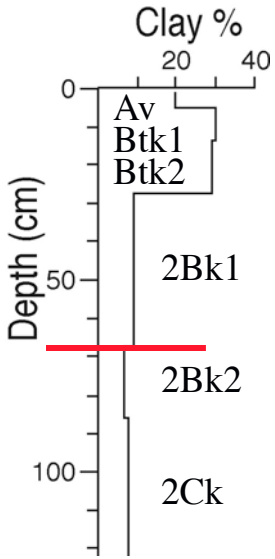
Knowing slopes, offsets, and estimate of mass diffusivity (m2/time)
Age of scarp can be estimated

Soil pit exposures and clay % depth profiles
Used to correlate map units and better understand the age of faulted deposits

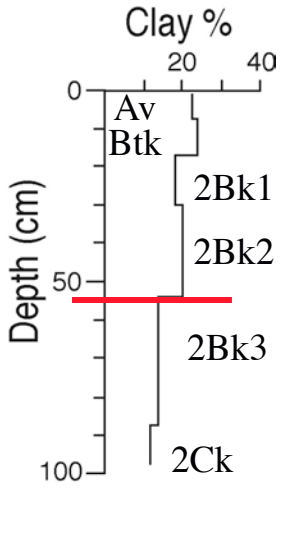
Desatoya



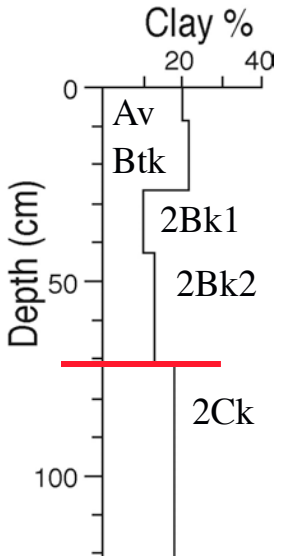
Toiyabe



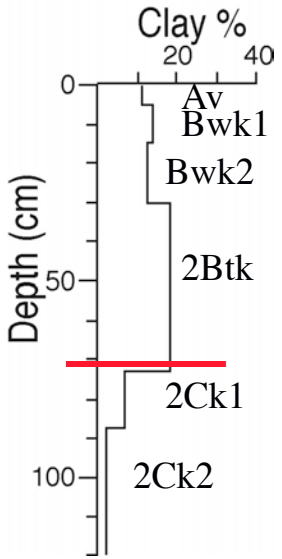
Butte



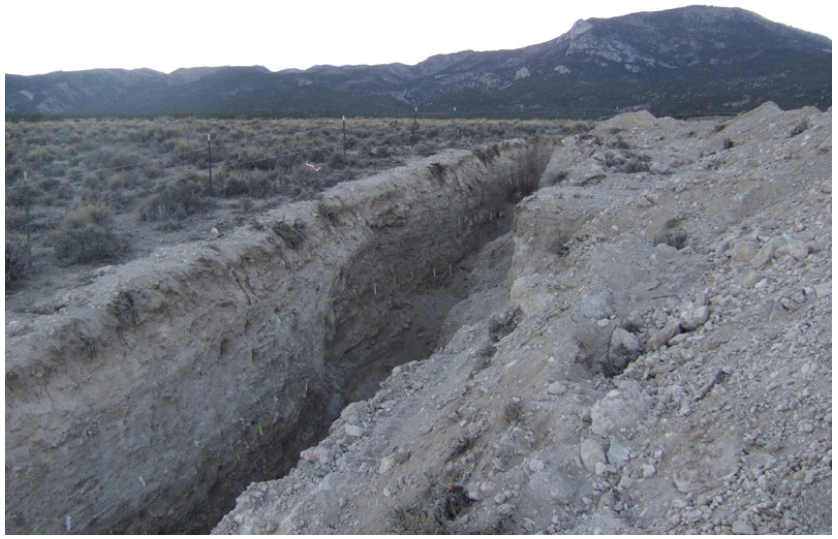
Egan



Schell Creek

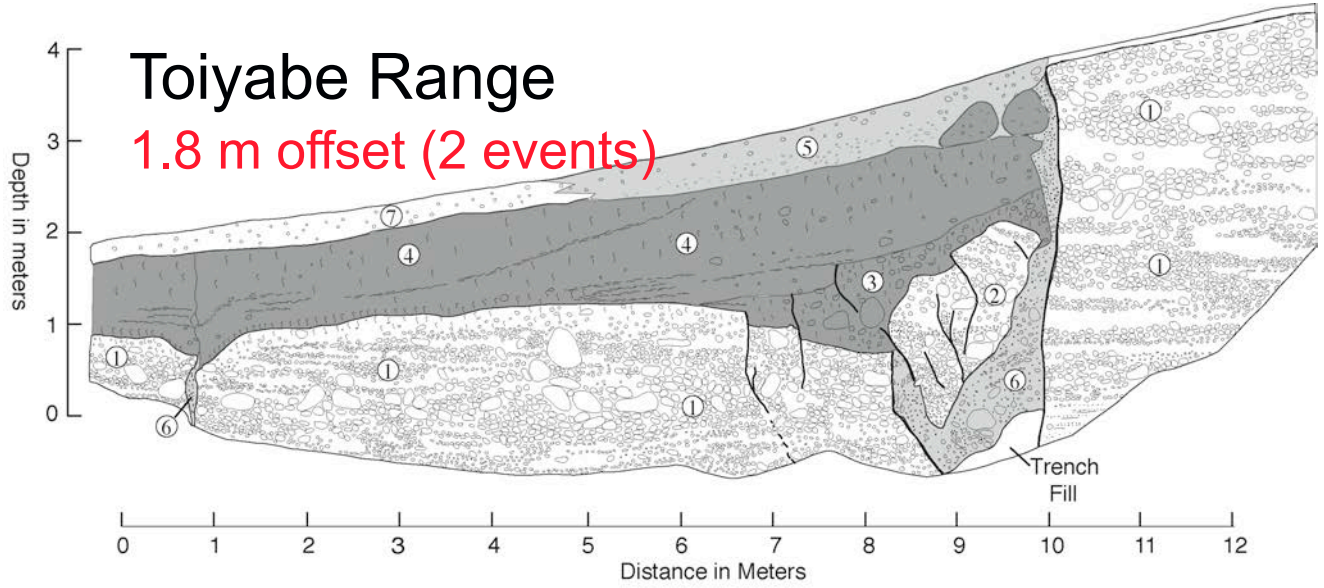


Trenching

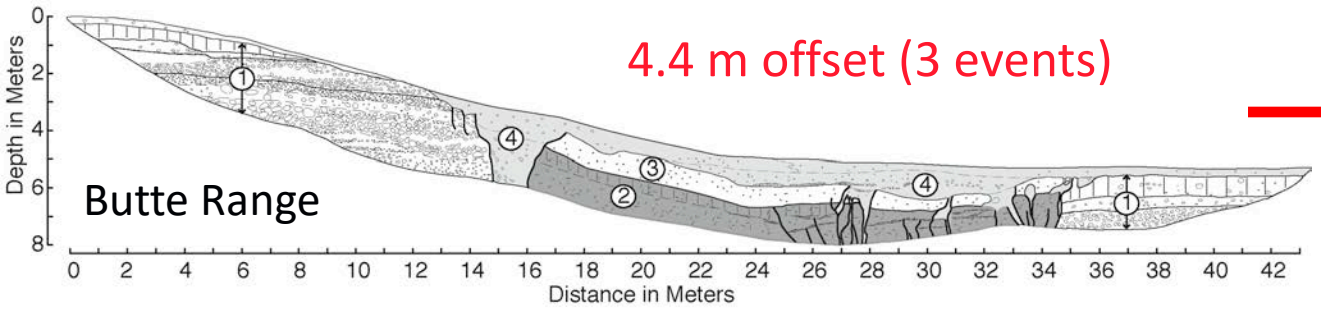


Toiyabe Range

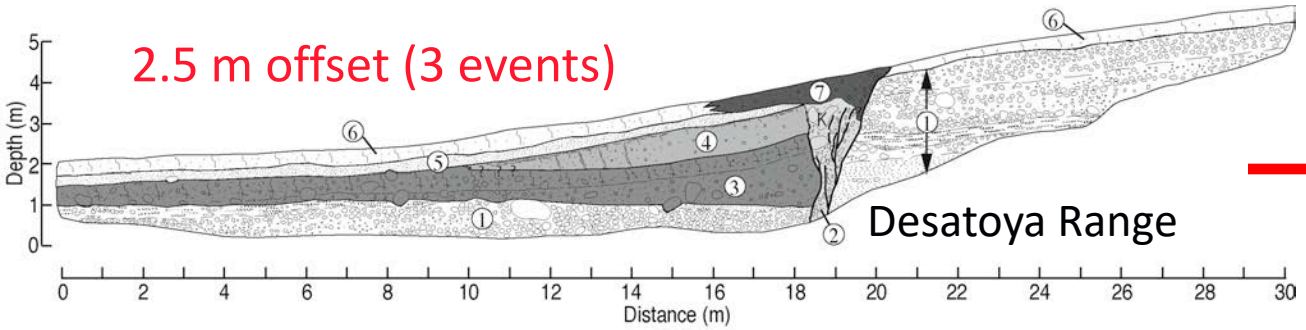
1.8 m offset (2 events)



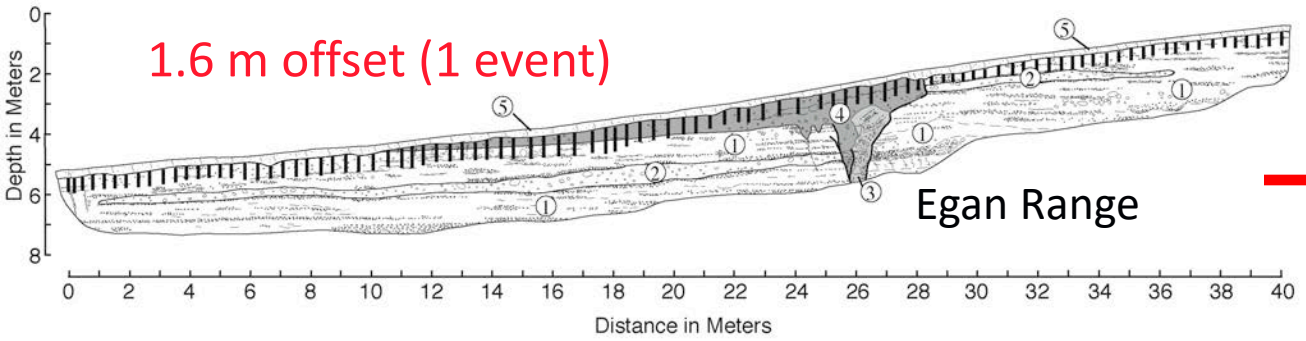
Trench Exposures



4.4 m offset (3 events)



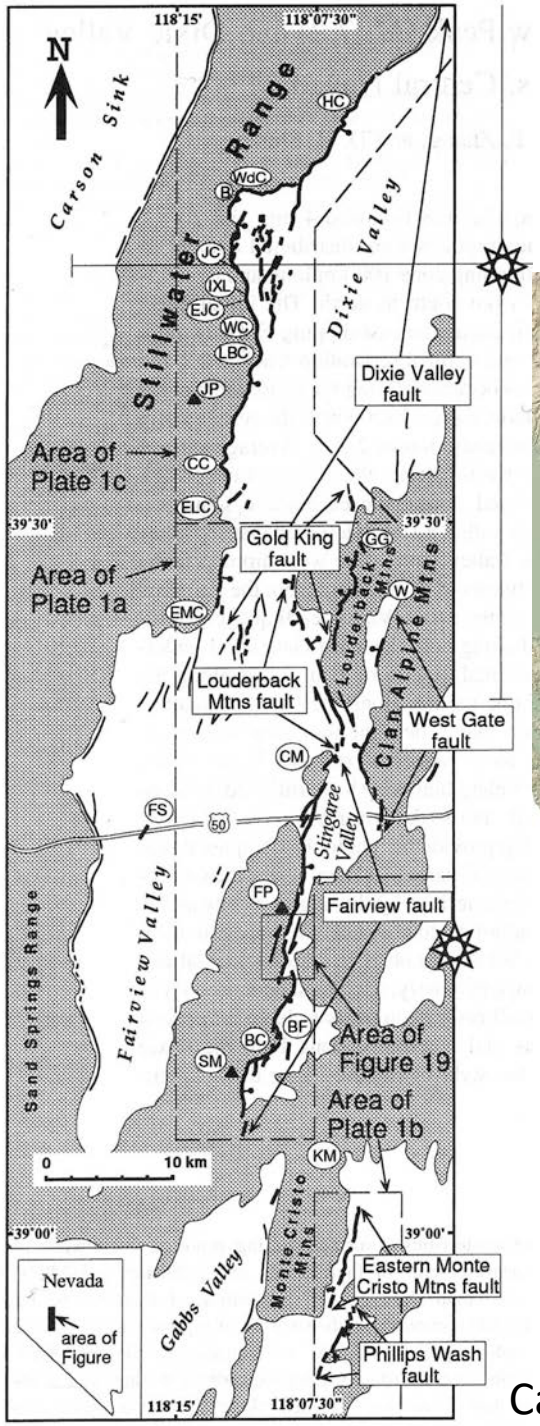
2.5 m offset (3 events)

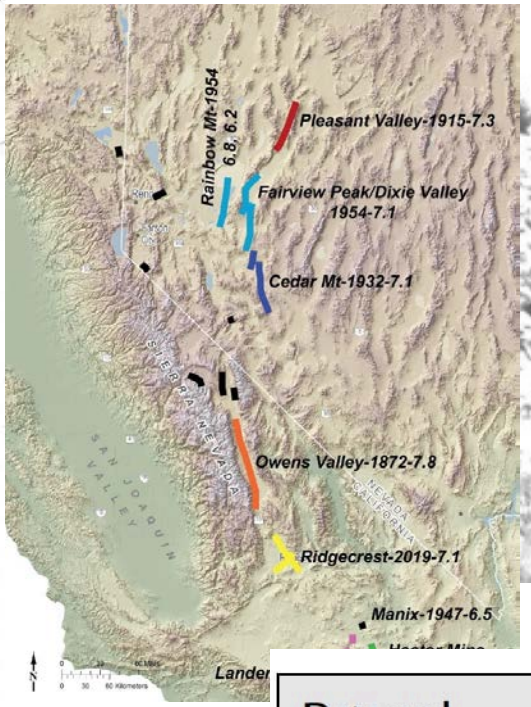


1.6 m offset (1 event)

Historical surface rupture examples

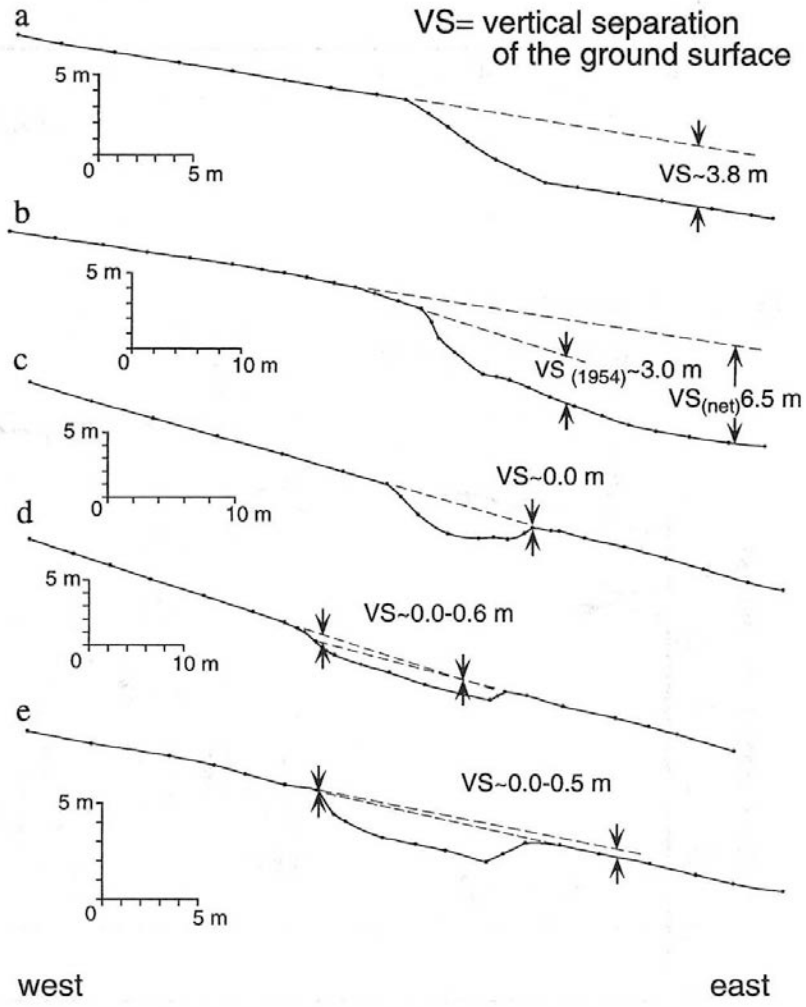
1954 Fairview Peak and Dixie Valley earthquakes





Date and magnitude	Area/fault	Maximum displacement[a] (m)	Length of rupture[a] (km)	References
a. Ruptures studied immediately after the earthquake				
1954, M_s 6.8	Dixie Valley, Nevada	3.8	45	Slemmons (1957)
1954, M_s 7.2	Fairview Peak, Nevada	4.8	67	Slemmons (1957)

Caskey et al., 1996



Caskey et al., 1996

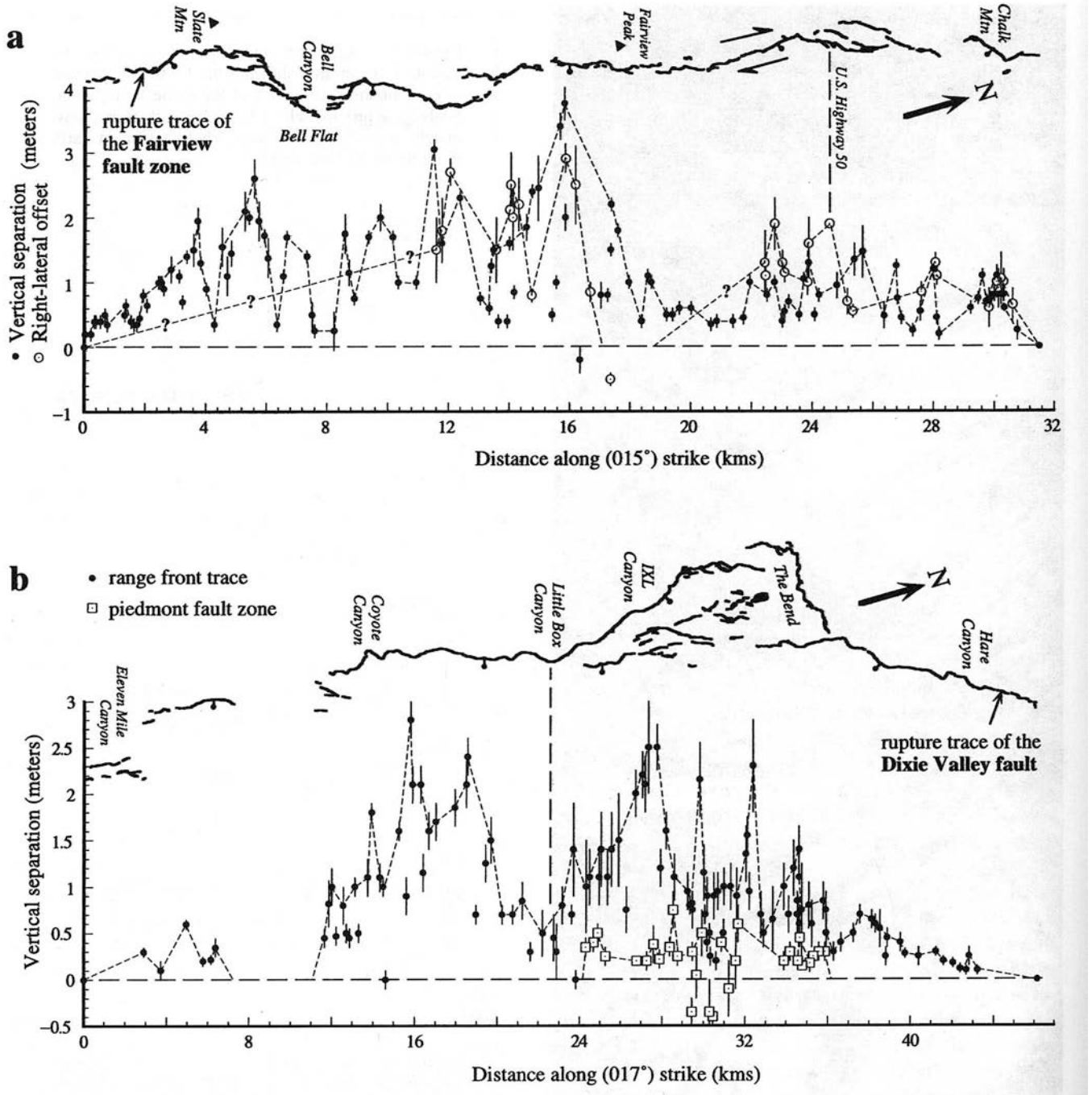
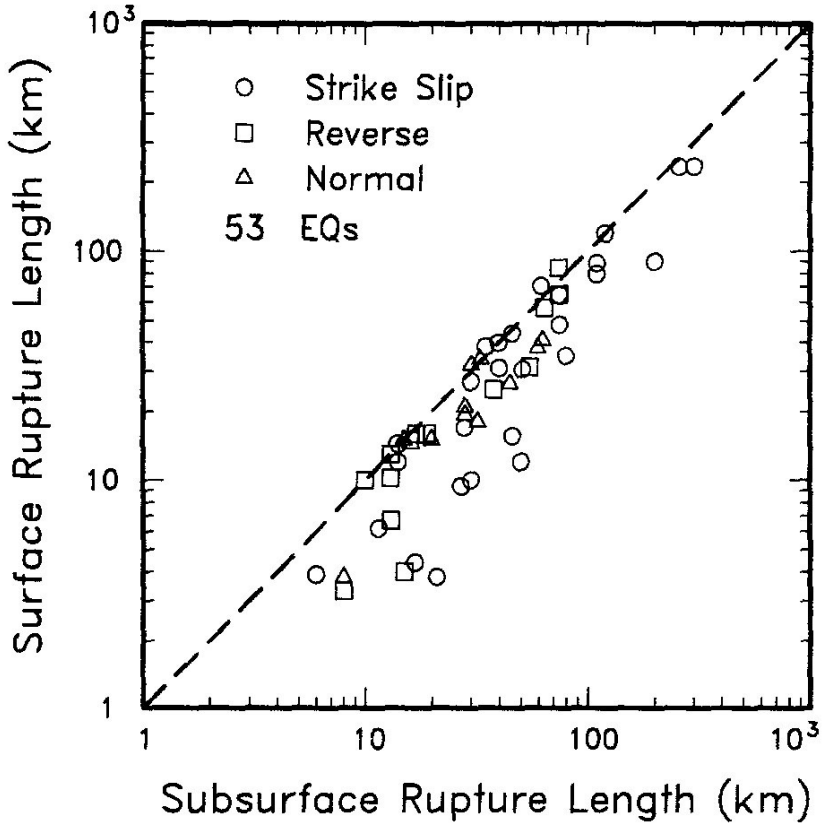


Table 2C
Regressions of Surface Rupture Length and Displacement

Equation*	Slip Type†	Number of Events	Coefficients and Standard Errors		Standard Deviation	Correlation Coefficient	Displacement Range (m)	Rupture Length Range (km)
			a(sa)	b(sb)	s	r		
log (MD) = a + b * log (SRL)	SS	55	−1.69(0.16)	1.16(0.09)	0.36	0.86	0.01 to 14.6	1.3 to 432
	{*R*‡	*21*	*−0.44(0.34)*	*0.42(0.23)*	*0.43*	*0.38*	*0.11 to 6.5*	*4 to 148*}
	N	19	−1.98(0.50)	1.51(0.35)	0.41	0.73	0.06 to 6.4	3.8 to 75
	All	95	−1.38(0.15)	1.02(0.09)	0.41	0.75	0.01 to 14.6	1.3 to 432
log (SRL) = a + b * log (MD)	SS	55	1.49(0.04)	0.64(0.05)	0.27	0.86	0.01 to 14.6	1.3 to 432
	{*R*	*21*	*1.36(0.09)*	*0.35(0.19)*	*0.39*	*0.38*	*0.11 to 6.5*	*4 to 148*}
	N	19	1.36(0.05)	0.35(0.08)	0.20	0.73	0.06 to 6.4	3.8 to 75
	All	95	1.43(0.03)	0.56(0.05)	0.31	0.75	0.01 to 14.6	1.3 to 432
log (AD) = a + b * log (SRL)	SS	35	−1.70(0.23)	1.04(0.13)	0.32	0.82	0.10 to 8.0	3.8 to 432
	{*R*	*17*	*−0.60(0.39)*	*0.31(0.27)*	*0.40*	*0.28*	*0.06 to 2.6*	*6.7 to 148*}
	N	14	−1.99(0.72)	1.24(0.49)	0.37	0.59	0.08 to 2.1	15 to 75
	All	66	−1.43(0.18)	0.88(0.11)	0.36	0.71	0.06 to 8.0	3.8 to 432
log (SRL) = a + b * log (AD)	SS	35	1.68(0.04)	0.65(0.08)	0.26	0.82	0.10 to 8.0	3.8 to 432
	{*R*	*17*	*1.45(0.10)*	*0.26(0.23)*	*0.36*	*0.28*	*0.06 to 2.6*	*6.7 to 148*}
	N	14	1.52(0.05)	0.28(0.11)	0.17	0.59	0.08 to 2.1	15 to 75
	All	66	1.61(0.04)	0.57(0.07)	0.29	0.71	0.06 to 8.0	3.8 to 432

*SRL—surface rupture length (km); MD—maximum displacement (m); AD—average displacement (m).
§SS—strike slip; R—reverse; N—normal.
‡Regressions for reverse-slip relationships shown in italics and brackets are not significant at a 95% probability level.



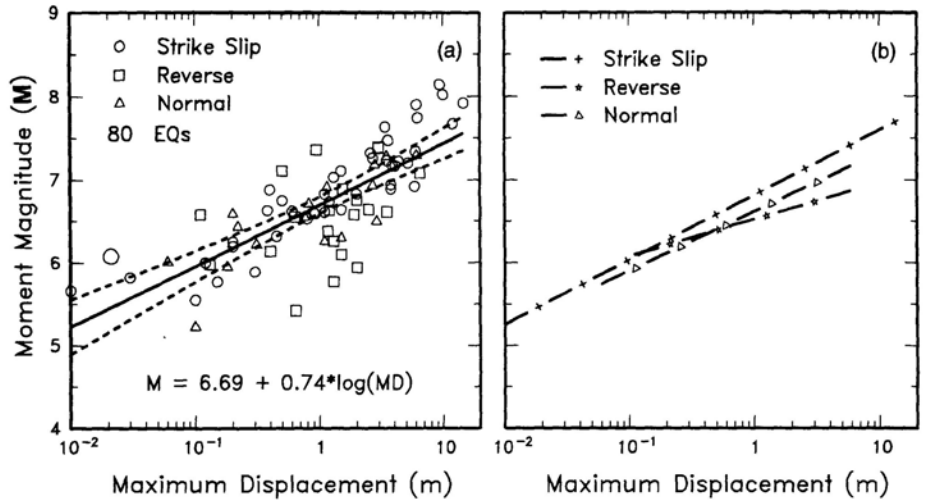


Figure 10. (a) Regression of maximum surface displacement on magnitude (**M**). Regression line shown for all-slip-type relationship. Short dashed line indicates 95% confidence interval. (b) Regression lines for strike-slip, reverse, and normal-slip relationships. See Table 2 for regression coefficients. Length of regression lines shows the range of data for each relationship.

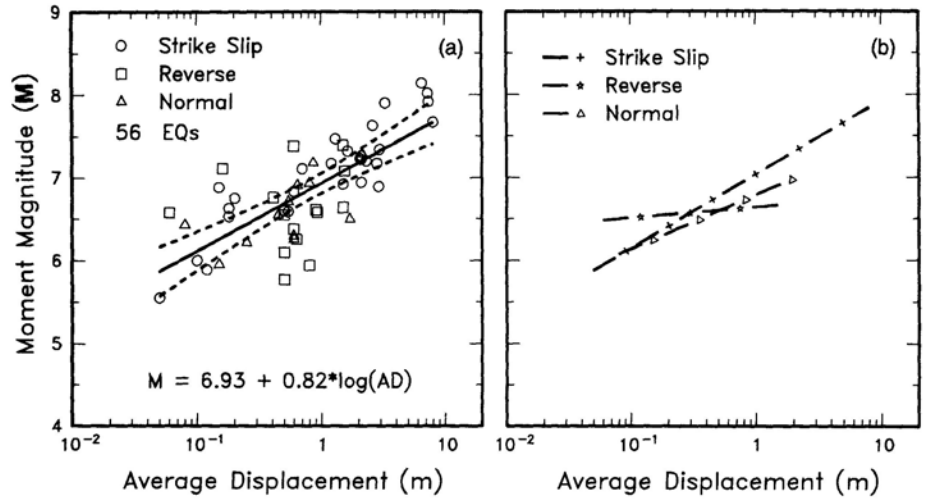


Figure 11. (a) Regression of average surface displacement on magnitude (**M**). Regression line shown for all-slip-type relationship. Short dashed line indicates 95% confidence interval. (b) Regression lines for strike-slip, reverse, and normal-slip relationships. See Table 2 for regression coefficients. Length of regression lines shows the range of data for each relationship.