LEHIGH UNIVERSITY

Fluvial responses to base level, climate, and active tectonics: South Anna River, central Appalachian Piedmont, Louisa County, Virginia

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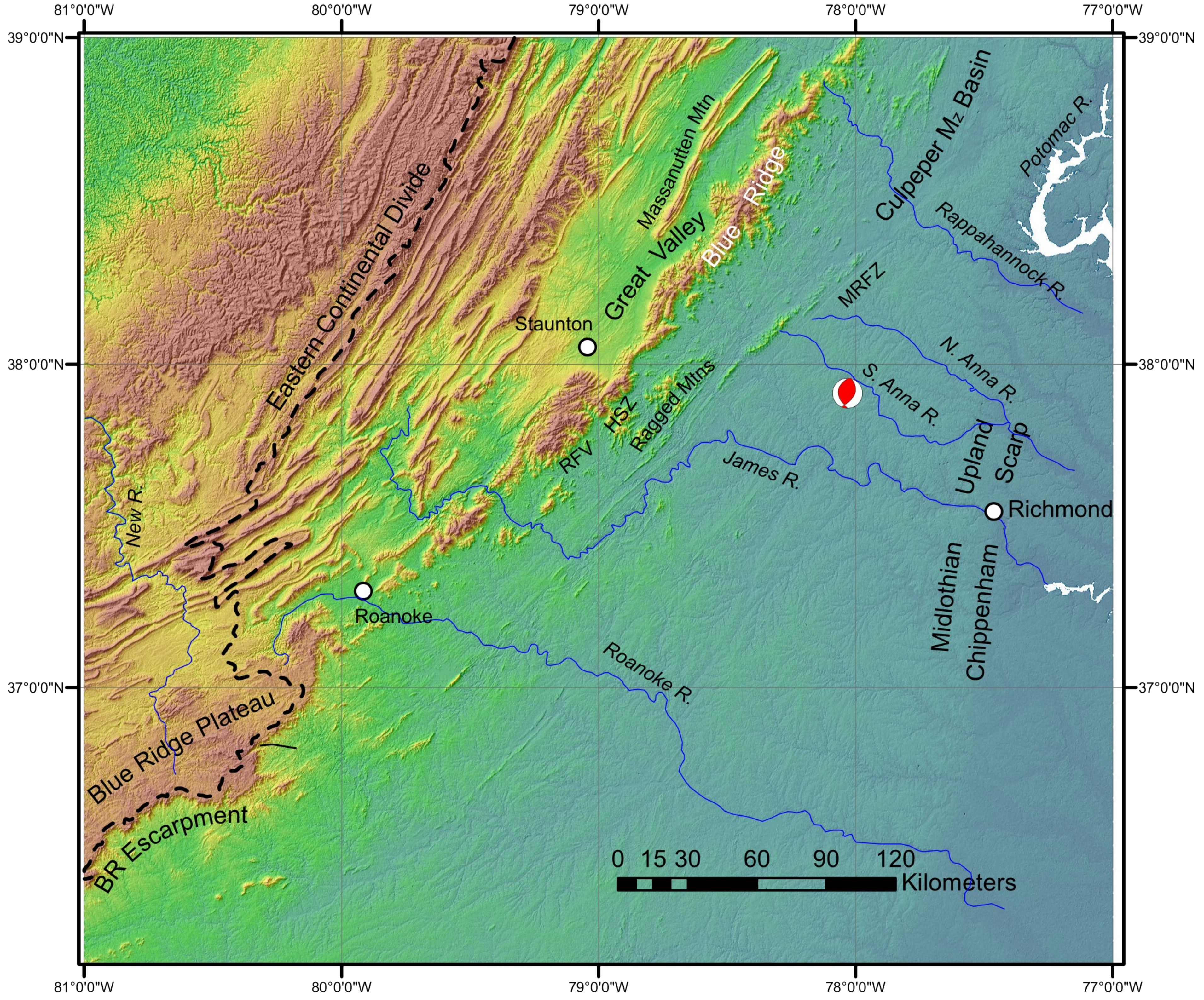
River incision is unsteady because,

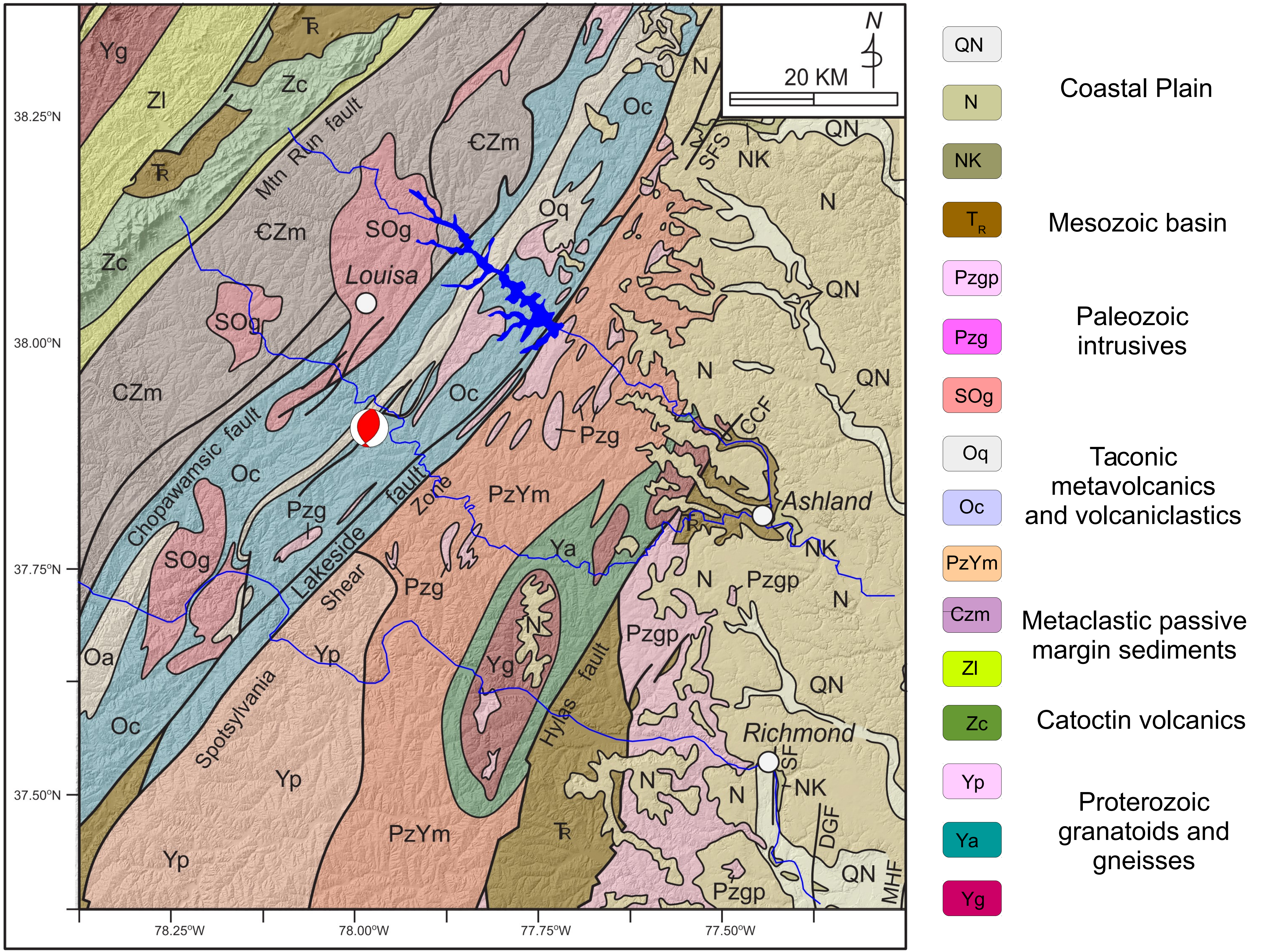
Climate is unsteady
Base level fall is unsteady
Stochastic processes, complex-response, thresholds

NSF EAR 1202798 (EarthScope RAPID) and USGS EDMAP - G13AC00115

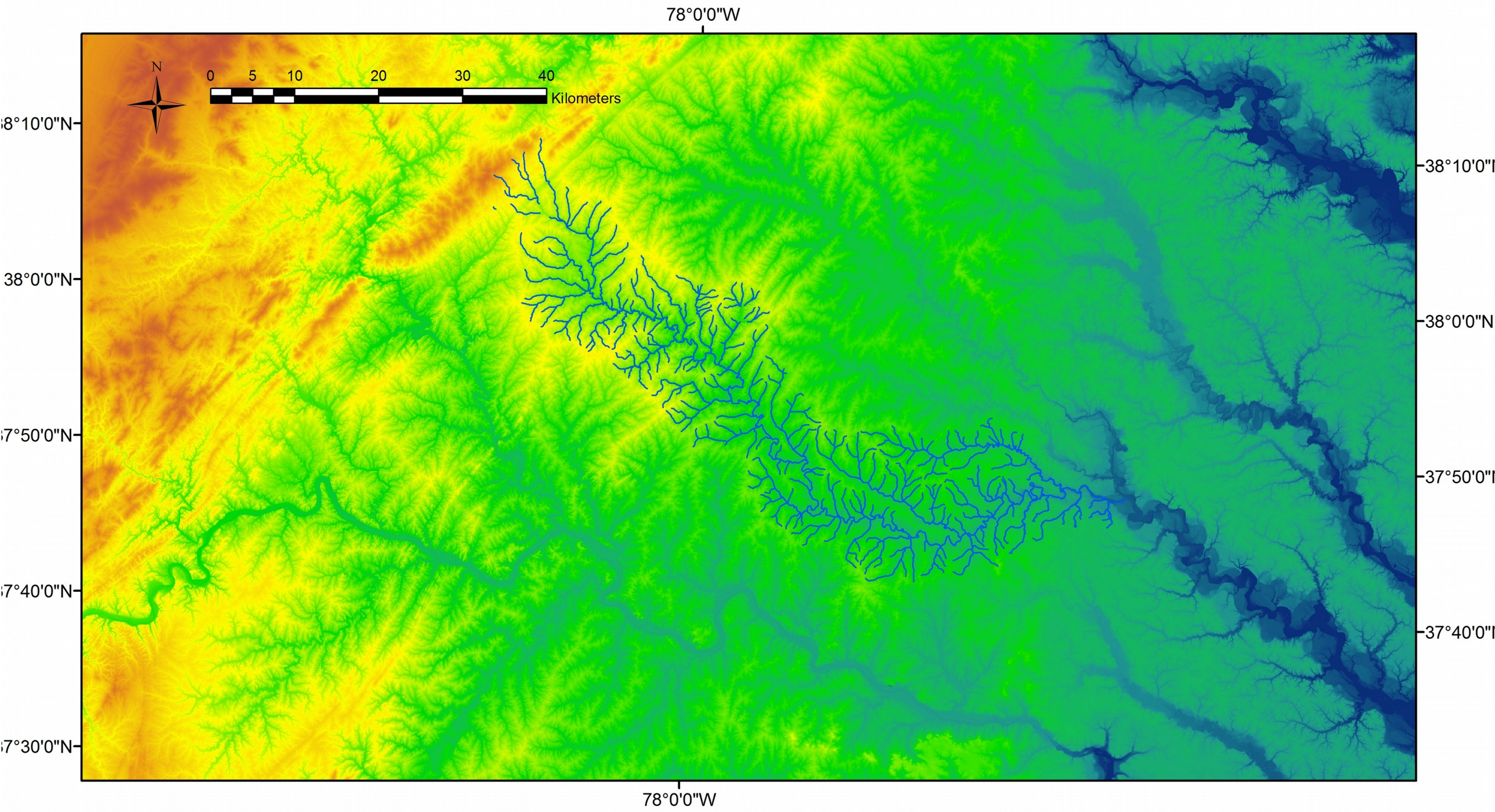
science for a changing world



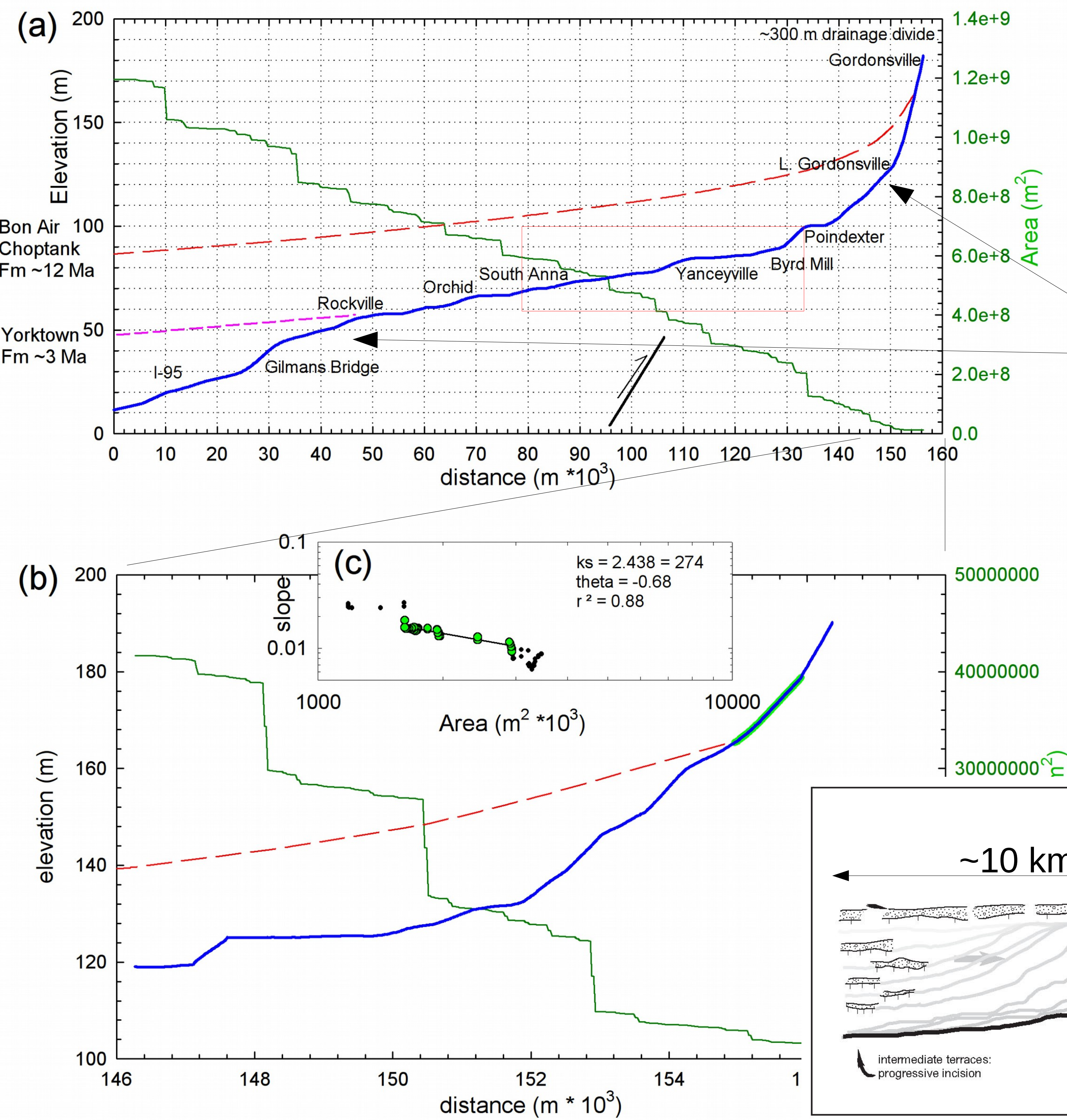
81°0'0"W
80°0'0"W
79°0'0"W
78°0'0"W
77°0'0"W
39°0'0"N
38°0'0"N
37°0'0"N
Eastern Continental Divide
Massanutten Mtn
Great Valley
Blue Ridge
Culpeper Mz Basin
Potomac R.
Rappahannock R.
MRFZ
Staunton
N. Anna R.
S. Anna R.
Ragged Mtns
HSZ
RFV
James R.
Upland Scarp
Richmond
New R.
Roanoke
Midlothian
Chippenham
Roanoke R.
Blue Ridge Plateau
BR Escarpment
0 15 30 60 90 120 Kilometers



N
20 KM
38.25°N
38.00°N
37.75°N
37.50°N
78.25°W
78.00°W
77.75°W
77.50°W
Mtn Run fault
Chopawamsic fault
Lakeside fault zone
Shear
Spotsylvania
Hylas fault
Louisa
Ashland
Richmond
SFS
CCF
SF
DGF
MHF
Yg
Zl
Zc
ЄZm
CZm
SOg
Oq
Oc
Oa
Pzg
PzYm
Ya
Yp
Pzgp
N
NK
QN
QN
N
NK
TR
Mesozoic basin
Pzgp
Pzg
SOg
Paleozoic intrusives
Oq
Oc
Taconic metavolcanics and volcaniclastics
PzYm
Czm
Zl
Metaclastic passive margin sediments
Zc
Catoctin volcanics
Yp
Ya
Yg
Proterozoic granatoids and gneisses
Coastal Plain



78°0'0"W
N
0
5
10
20
30
40
Kilometers
38°10'0"N
38°0'0"N
37°50'0"N
37°40'0"N
37°30'0"N
38°10'0"N
38°0'0"N
37°50'0"N
37°40'0"N
78°0'0"W



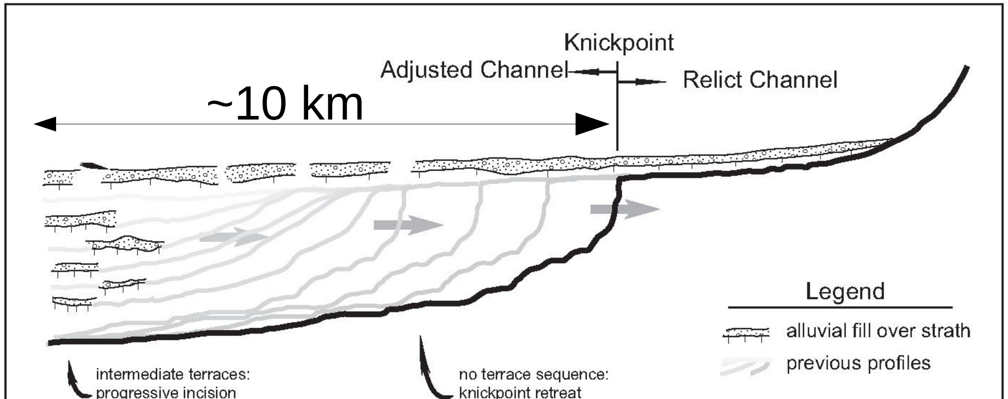
Sources of incision unsteadiness

Climate
Base level fall
Complex Response

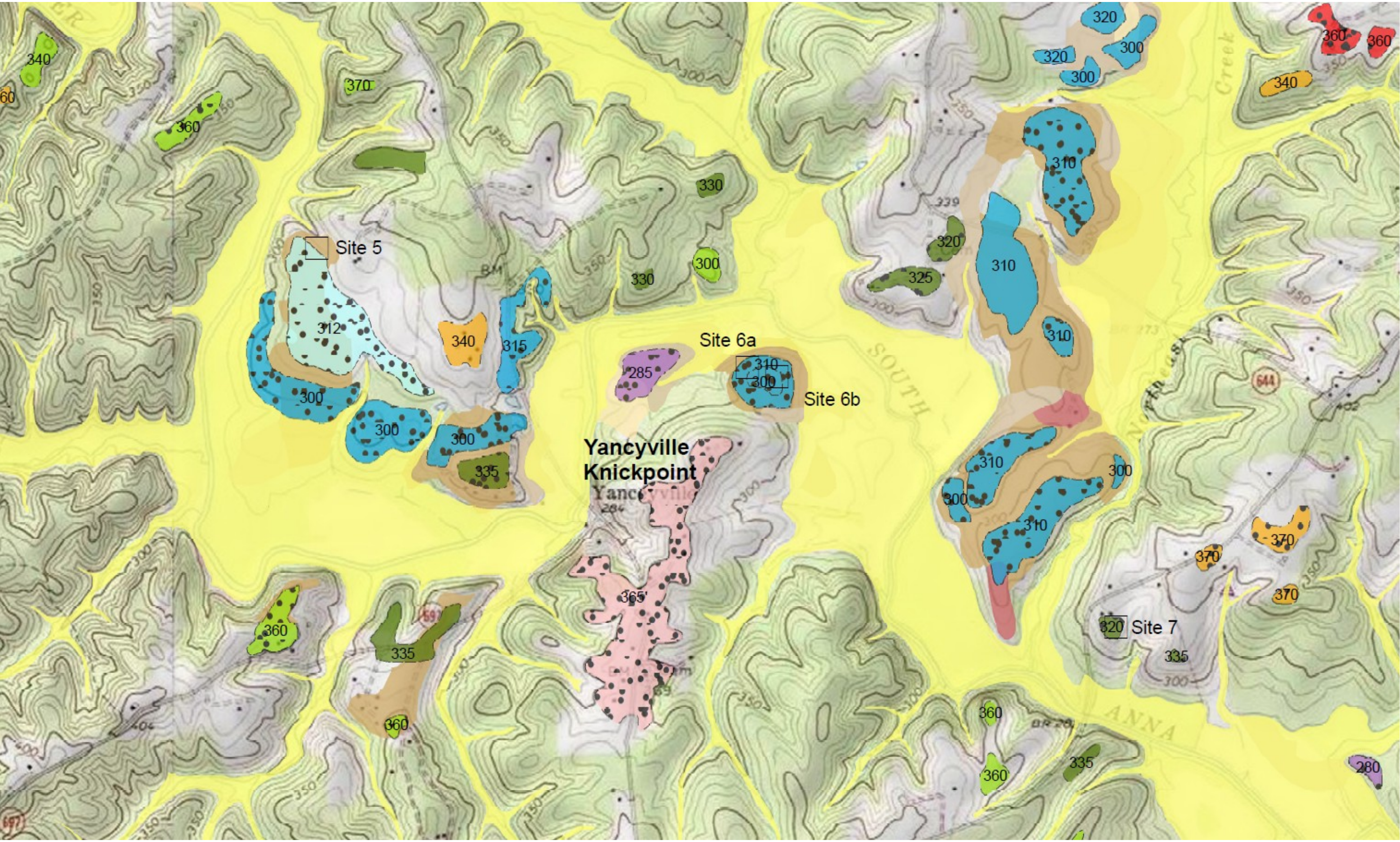
Two large knickzones

Knickpoint celerity modeling suggests that individual knickpoints are moving 7 – 14 km/m.y. in this zone

so....an individual terrace tread could range in age 10^5-10^6 yrs in this zone

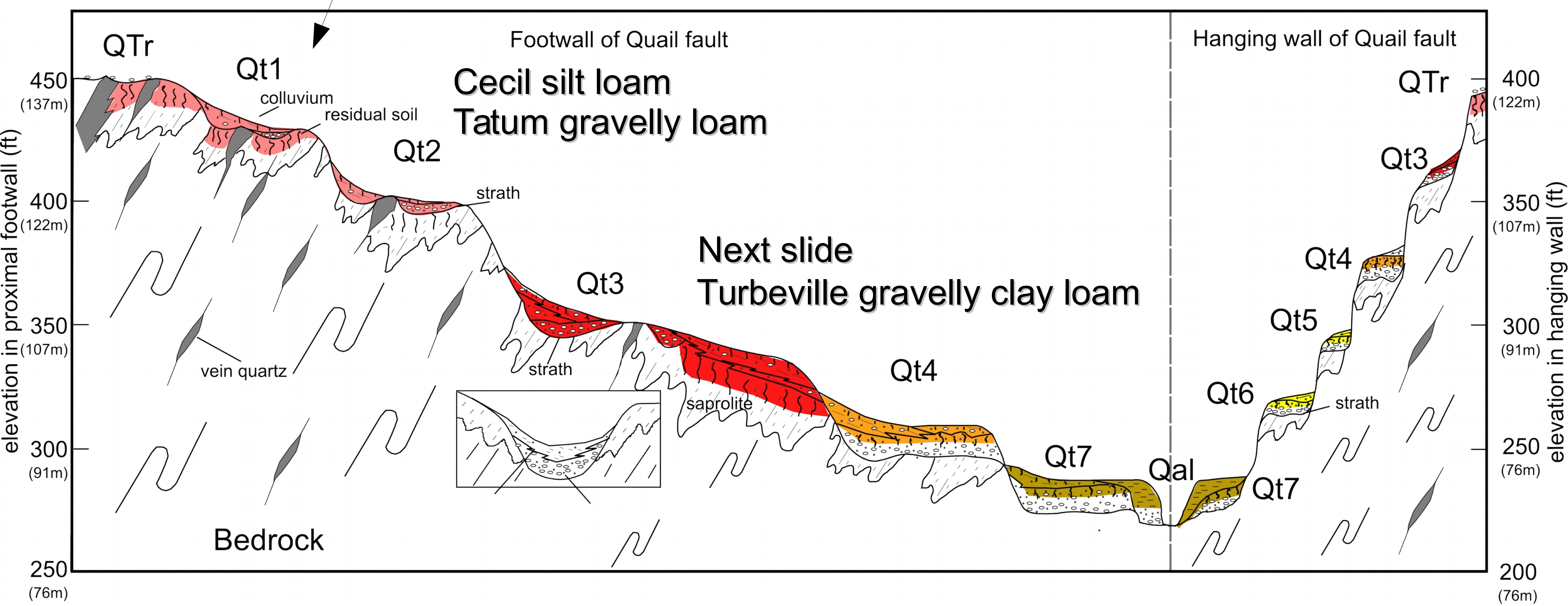


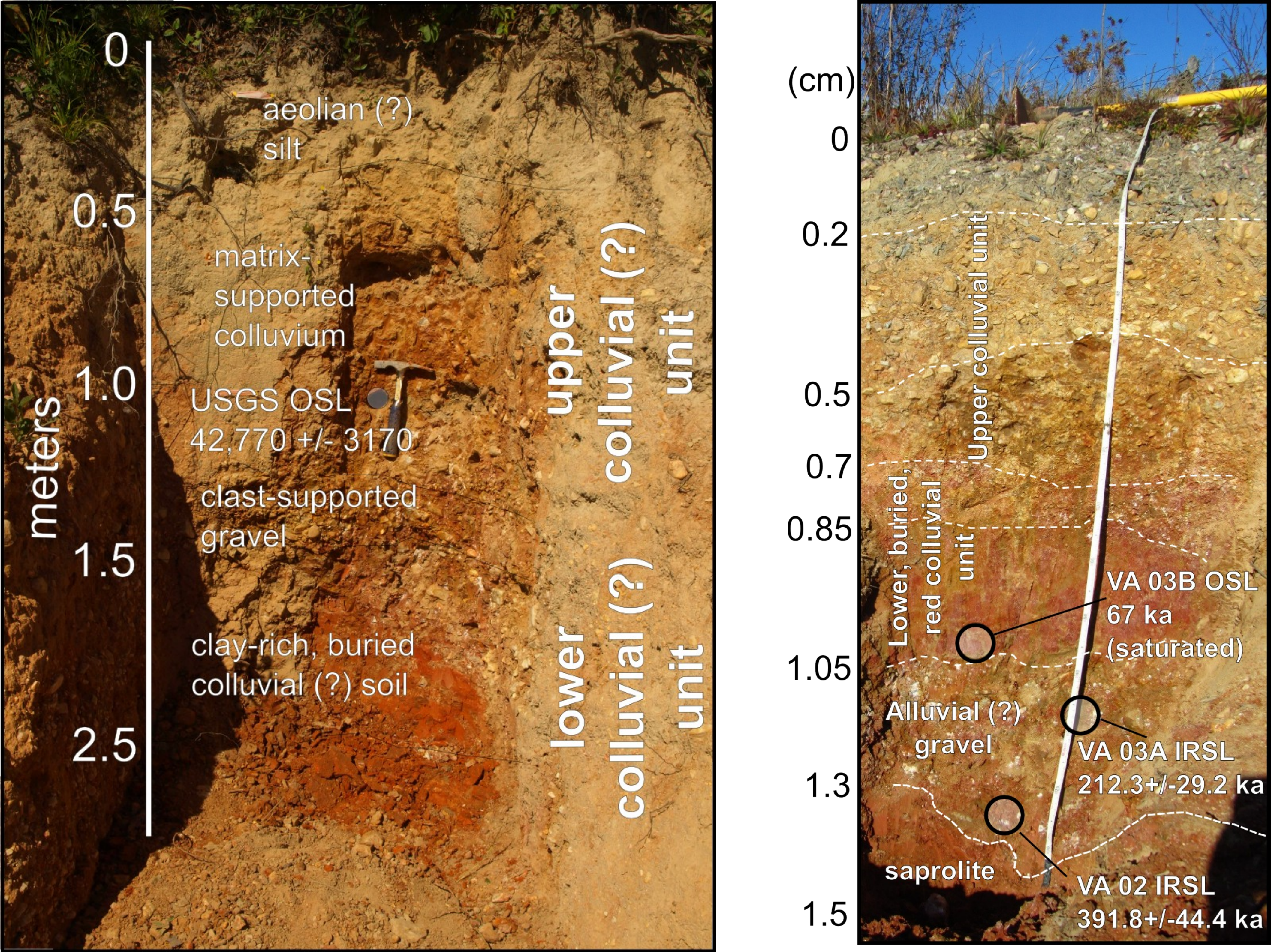
Crosby and Whipple (2006)



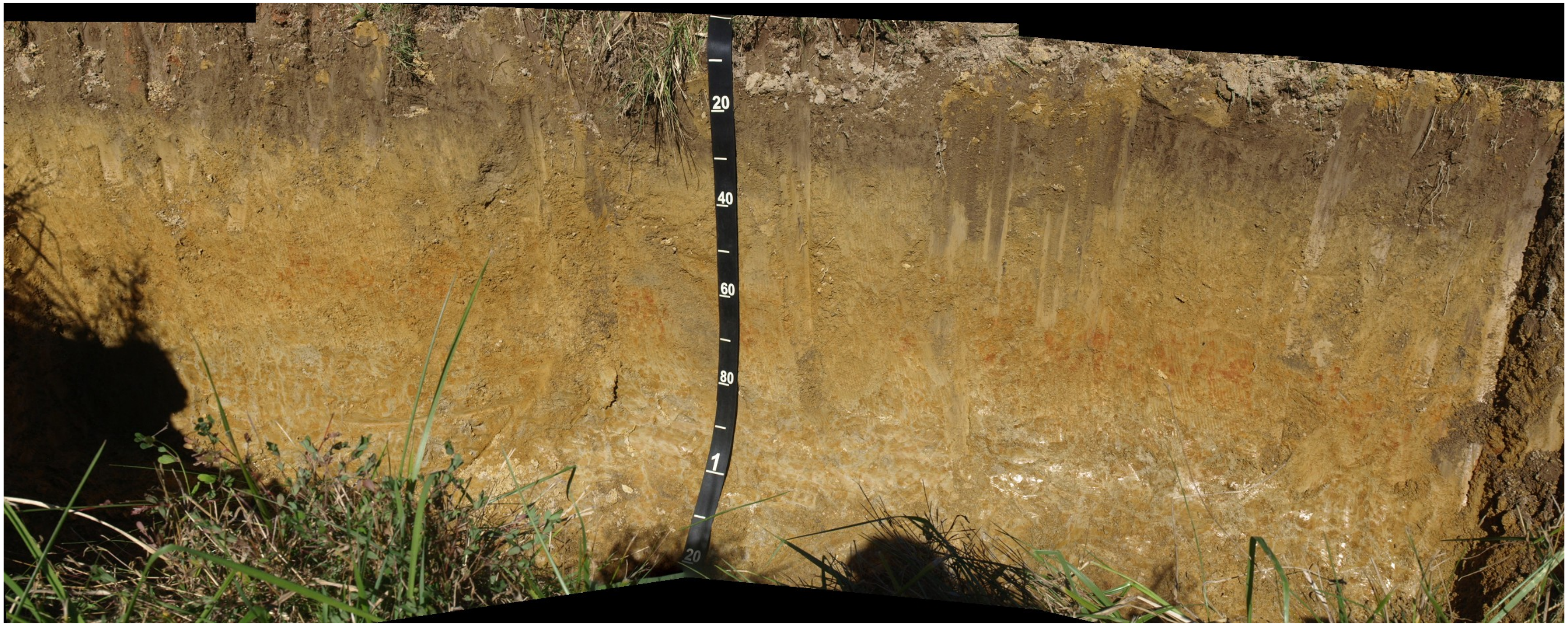
Mapping by Helen Malenda, EDMAP, 2014

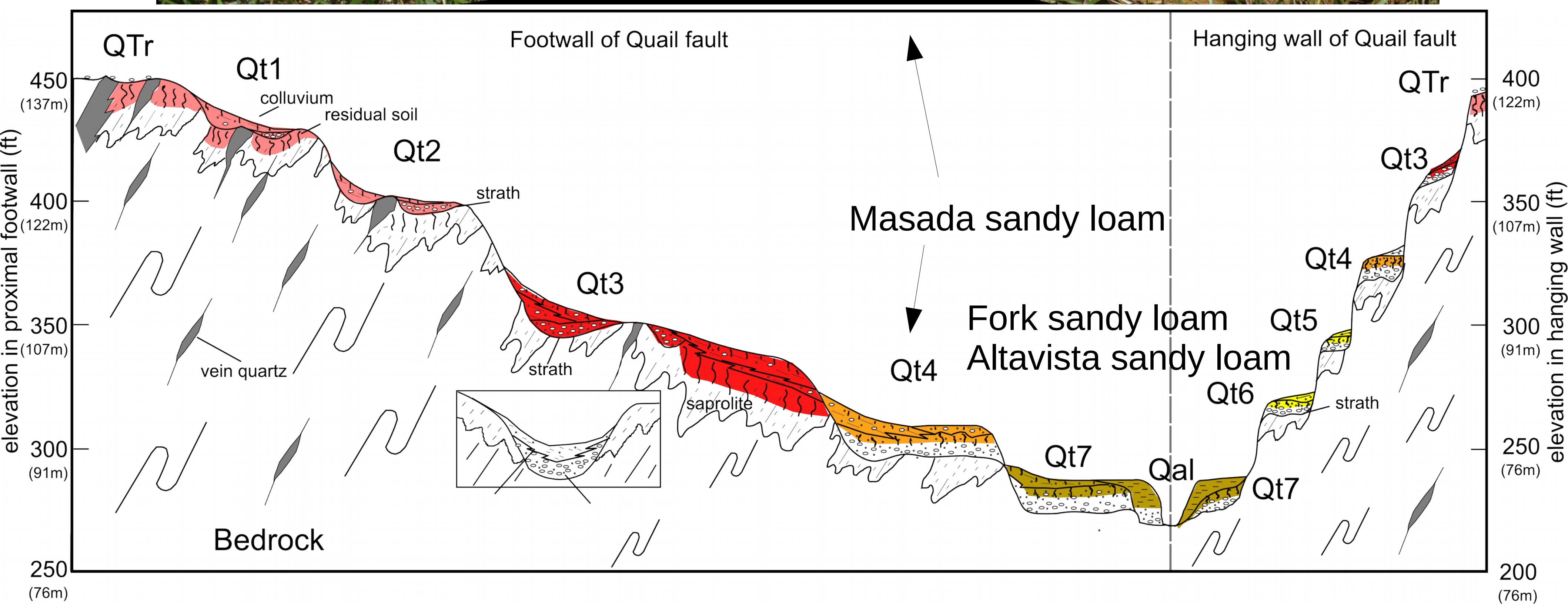

Pz
Vein
QTZ

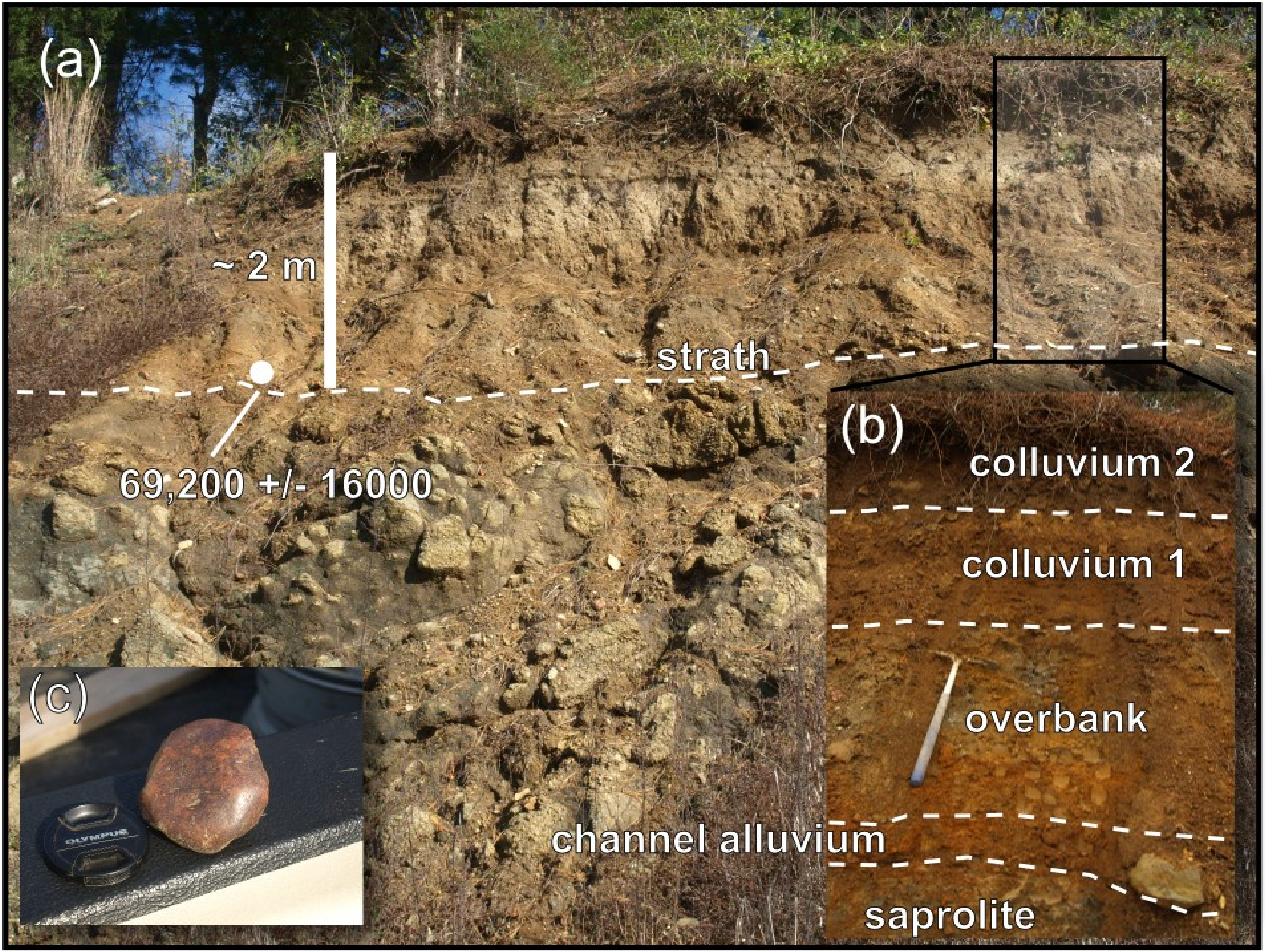

Footwall of Quail fault
Hanging wall of Quail fault
Cecil silt loam
Tatum gravelly loam
Next slide
Turbeville gravelly clay loam
QTr
Qt1
colluvium
residual soil
Qt2
strath
Qt3
strath
saprolite
Qt4
Qt7
Qal
Qt7
Qt6
strath
Qt5
Qt4
Qt3
QTr
vein quartz
Bedrock
elevation in proximal footwall (ft)
450
(137m)
400
(122m)
350
(107m)
300
(91m)
250
(76m)
elevation in hanging wall (ft)
400
(122m)
350
(107m)
300
(91m)
250
(76m)
200
(76m)

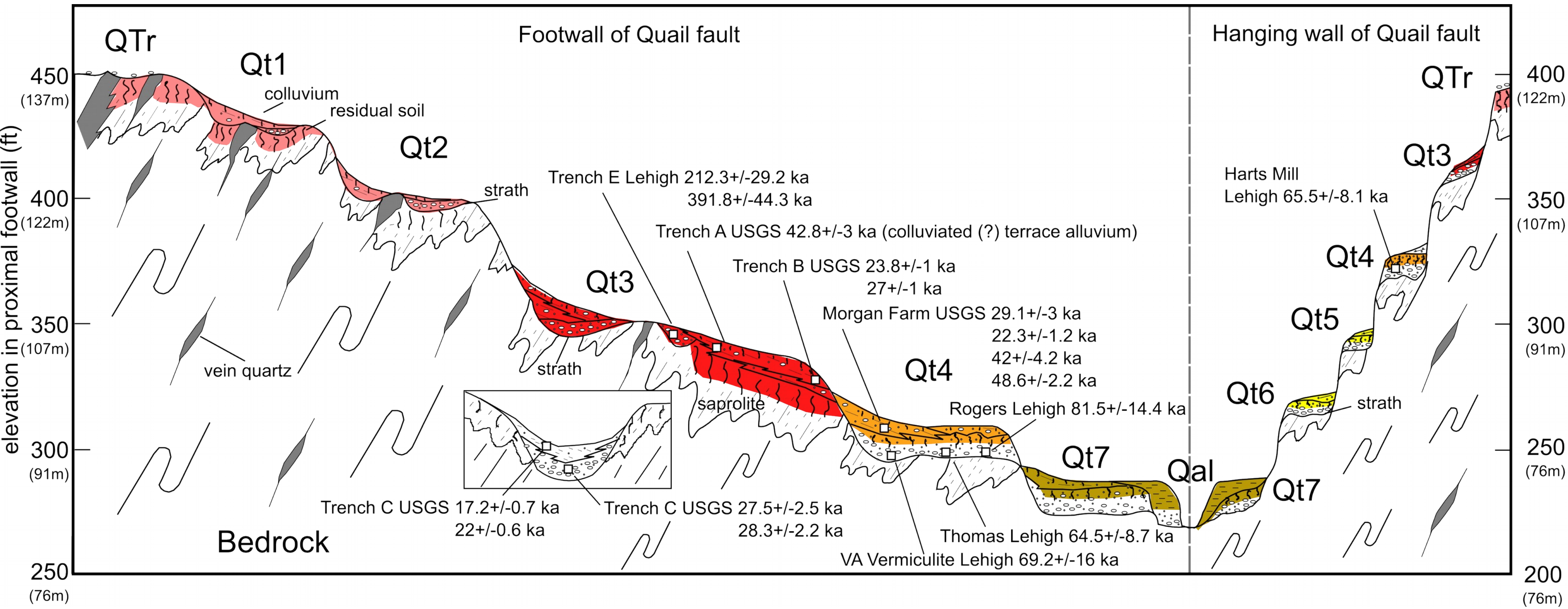


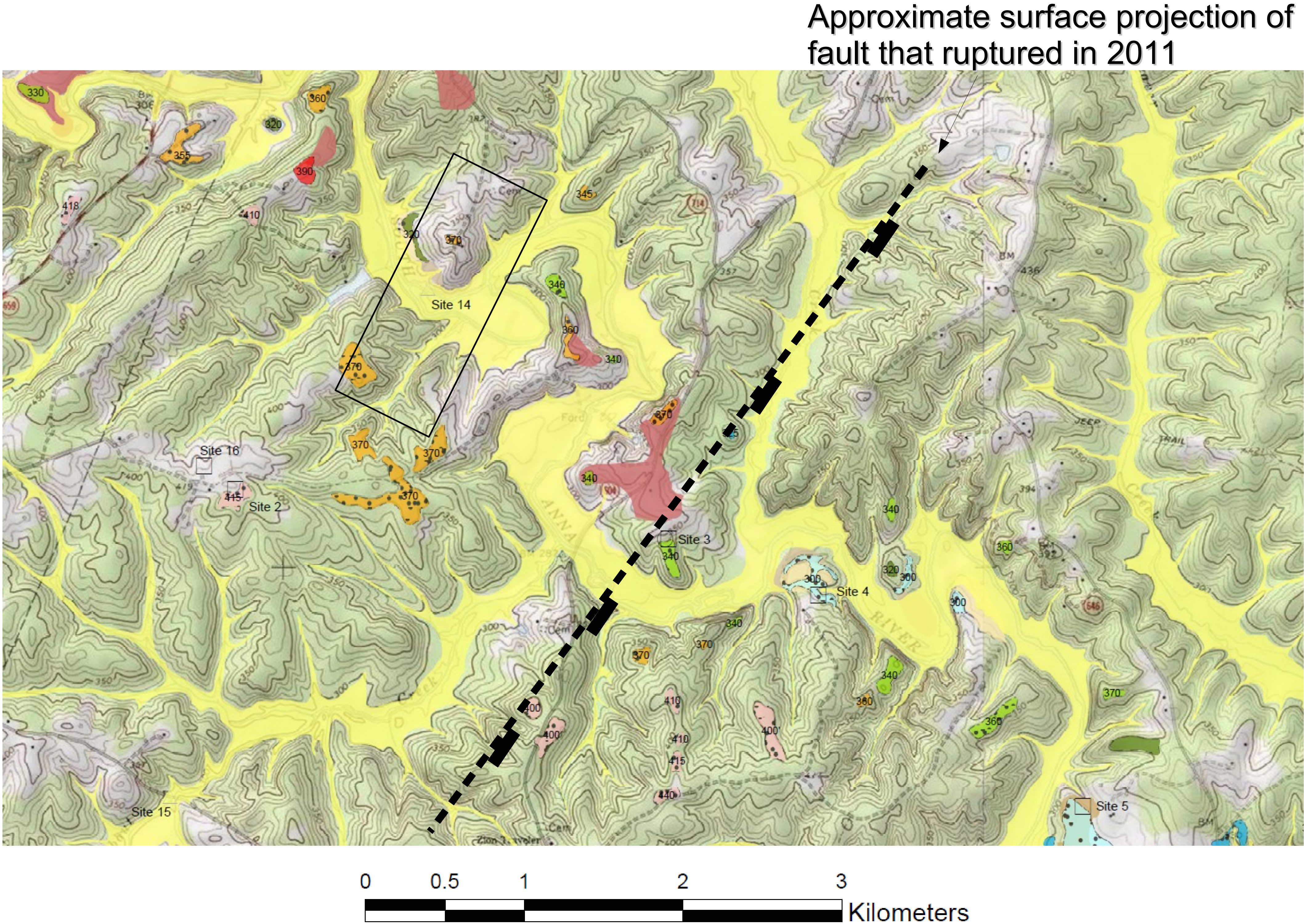
0
0.5
1.0
1.5
2.5
meters
aeolian (?) silt
matrix-supported colluvium
USGS OSL 42,770 +/- 3170
clast-supported gravel
clay-rich, buried colluvial (?) soil
upper colluvial (?) unit
lower colluvial (?) unit
(cm)
0
0.2
0.5
0.7
0.85
1.05
1.3
1.5
Upper colluvial unit
Lower, buried, red colluvial unit
VA 03B OSL 67 ka (saturated)
Alluvial (?) gravel
VA 03A IRSL 212.3+/-29.2 ka
saprolite
VA 02 IRSL 391.8+/-44.4 ka


20
40
60
80
1
20


QTr
Qt1
colluvium
residual soil
Qt2
strath
Footwall of Quail fault
Masada sandy loam
Fork sandy loam
Altavista sandy loam
Hanging wall of Quail fault
QTr
Qt3
Qt4
Qt5
Qt6
strath
Qt7
Qal
Qt7
Qt4
Qt3
strath
saprolite
vein quartz
Bedrock
450
(137m)
400
(122m)
350
(107m)
300
(91m)
250
(76m)
elevation in proximal footwall (ft)
400
(122m)
350
(107m)
300
(91m)
250
(76m)
200
(76m)
elevation in hanging wall (ft)


(a)
~ 2 m
strath
69,200 +/- 16000
(b)
colluvium 2
colluvium 1
overbank
channel alluvium
saprolite
(c)
OLYMPUS

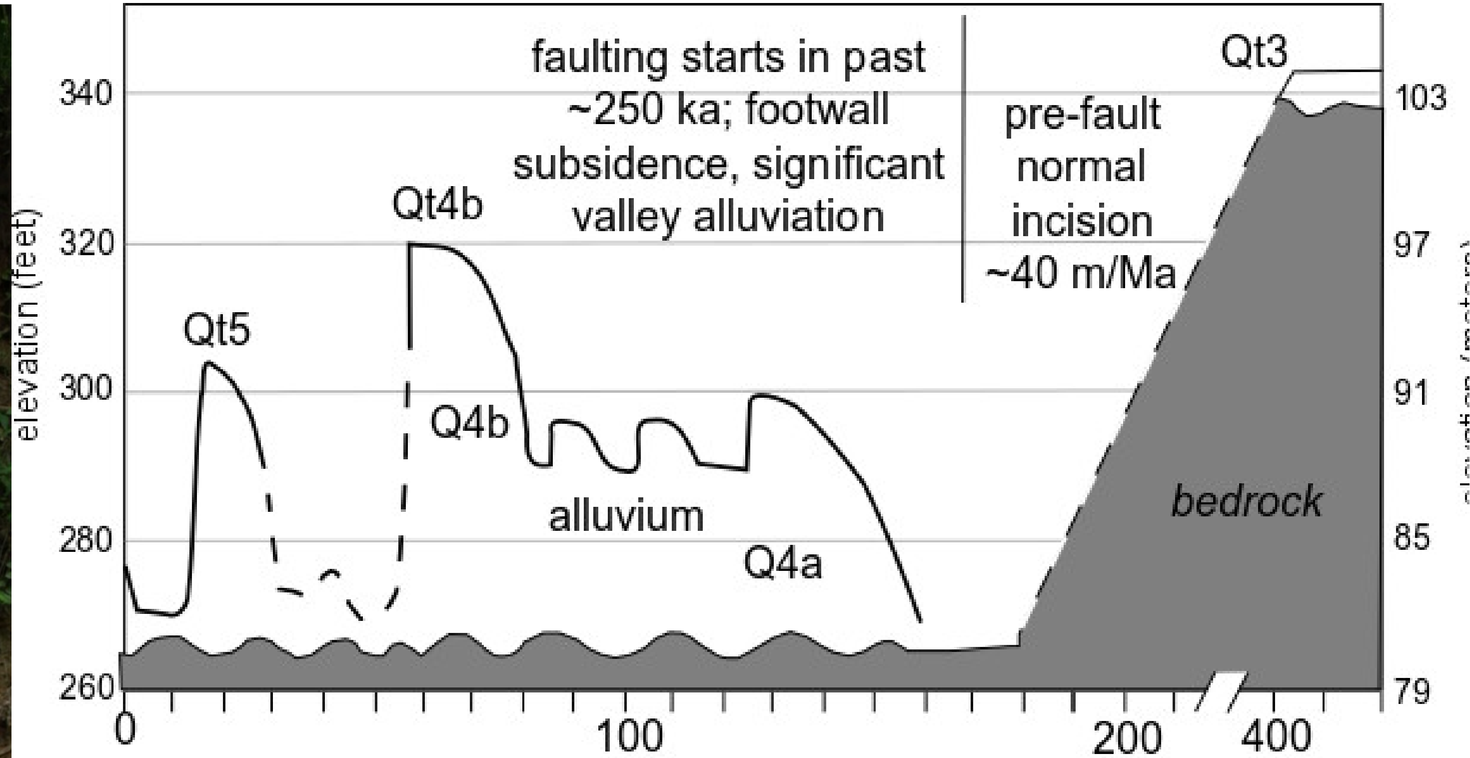

Footwall of Quail fault
Hanging wall of Quail fault
QTr
Qt1
colluvium
residual soil
Qt2
strath
Qt3
Trench E Lehigh 212.3+/-29.2 ka
391.8+/-44.3 ka
Trench A USGS 42.8+/-3 ka (colluviated (?) terrace alluvium)
Trench B USGS 23.8+/-1 ka
27+/-1 ka
Morgan Farm USGS 29.1+/-3 ka
22.3+/-1.2 ka
42+/-4.2 ka
48.6+/-2.2 ka
Qt4
Rogers Lehigh 81.5+/-14.4 ka
saprolite
strath
vein quartz
Qt7
Qal
Trench C USGS 17.2+/-0.7 ka
22+/-0.6 ka
Trench C USGS 27.5+/-2.5 ka
28.3+/-2.2 ka
Thomas Lehigh 64.5+/-8.7 ka
VA Vermiculite Lehigh 69.2+/-16 ka
Bedrock
Harts Mill
Lehigh 65.5+/-8.1 ka
QTr
Qt3
Qt4
Qt5
Qt6
strath
Qt7
450 (137m)
400 (122m)
350 (107m)
300 (91m)
250 (76m)
elevation in proximal footwall (ft)
400 (122m)
350 (107m)
300 (91m)
250 (76m)
200 (76m)
elevation in hanging wall (ft)

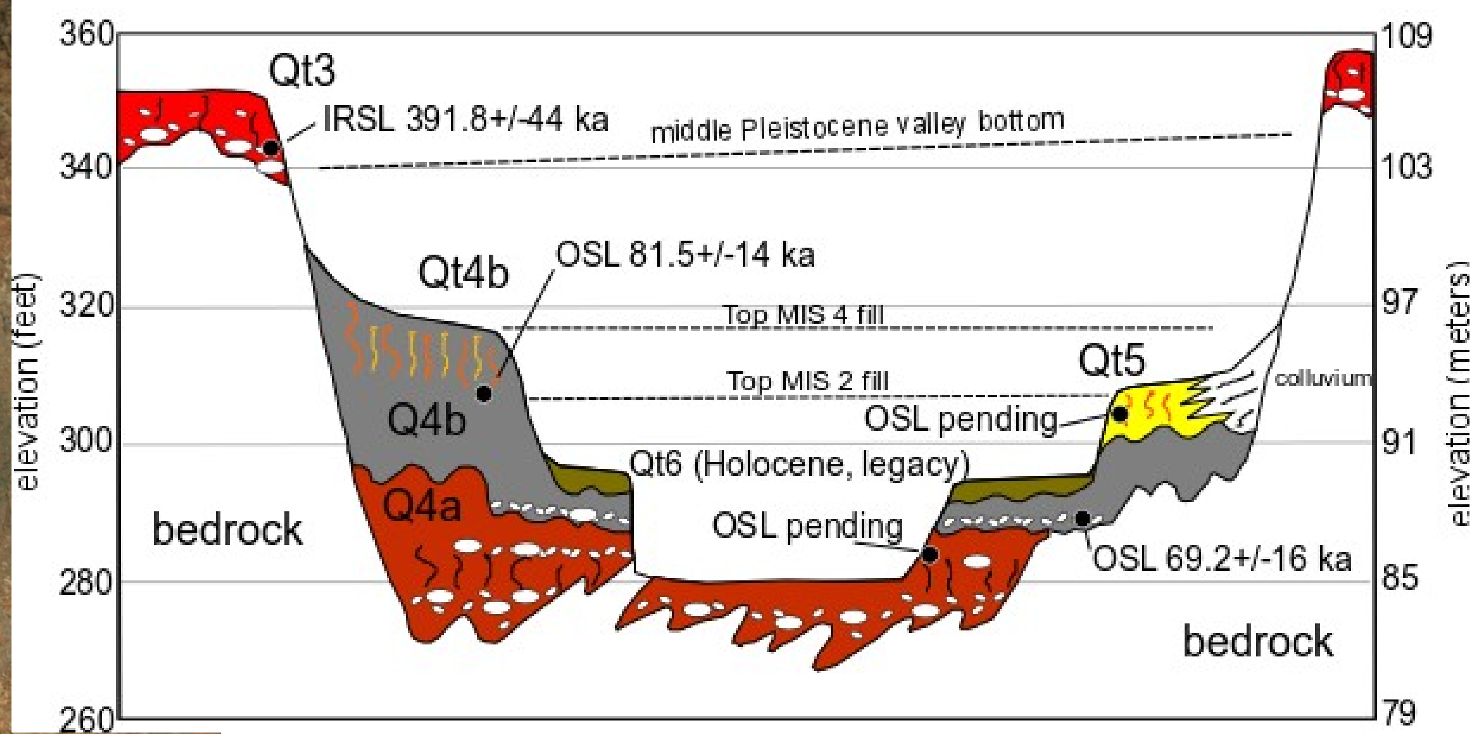


Approximate surface projection of fault that ruptured in 2011
Site 14
Site 16
Site 2
Site 3
Site 4
Site 5
Site 15
0
0.5
1
2
3
Kilometers

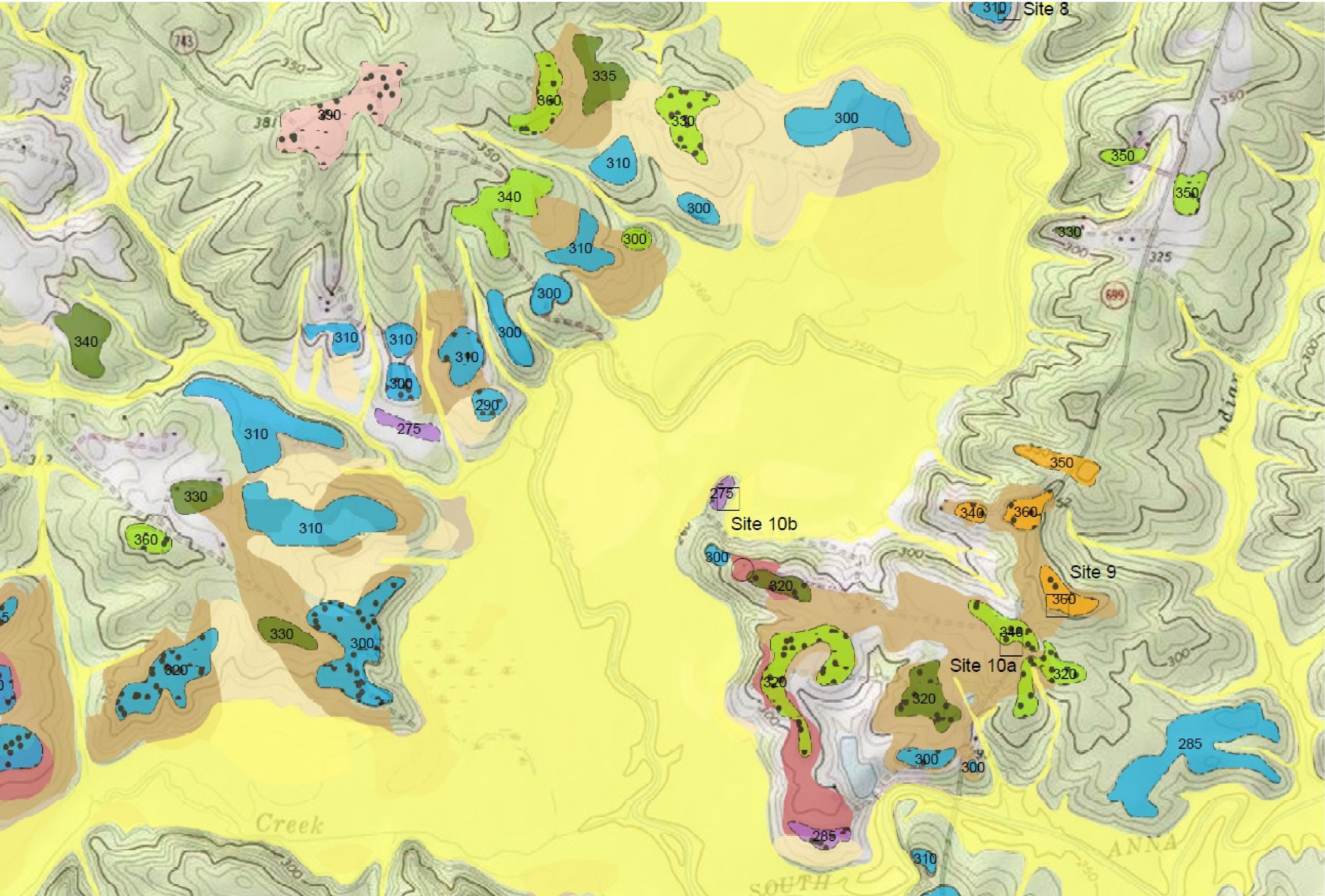
Sources of incision unsteadiness

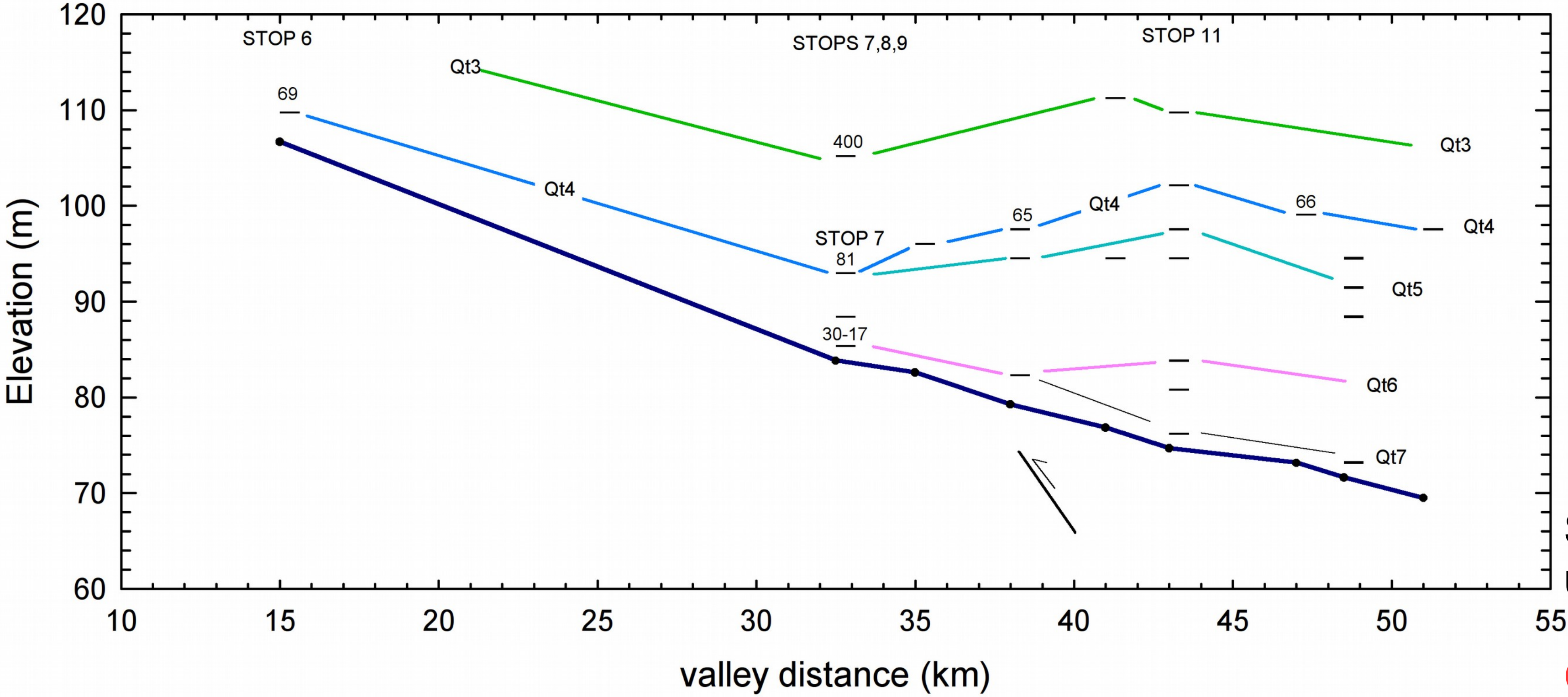
Climate
Base level fall
Complex response





There are many Qt4 deposits (~70 ka) and they are thick, representing a volume of alluvium greater than the legacy sediments



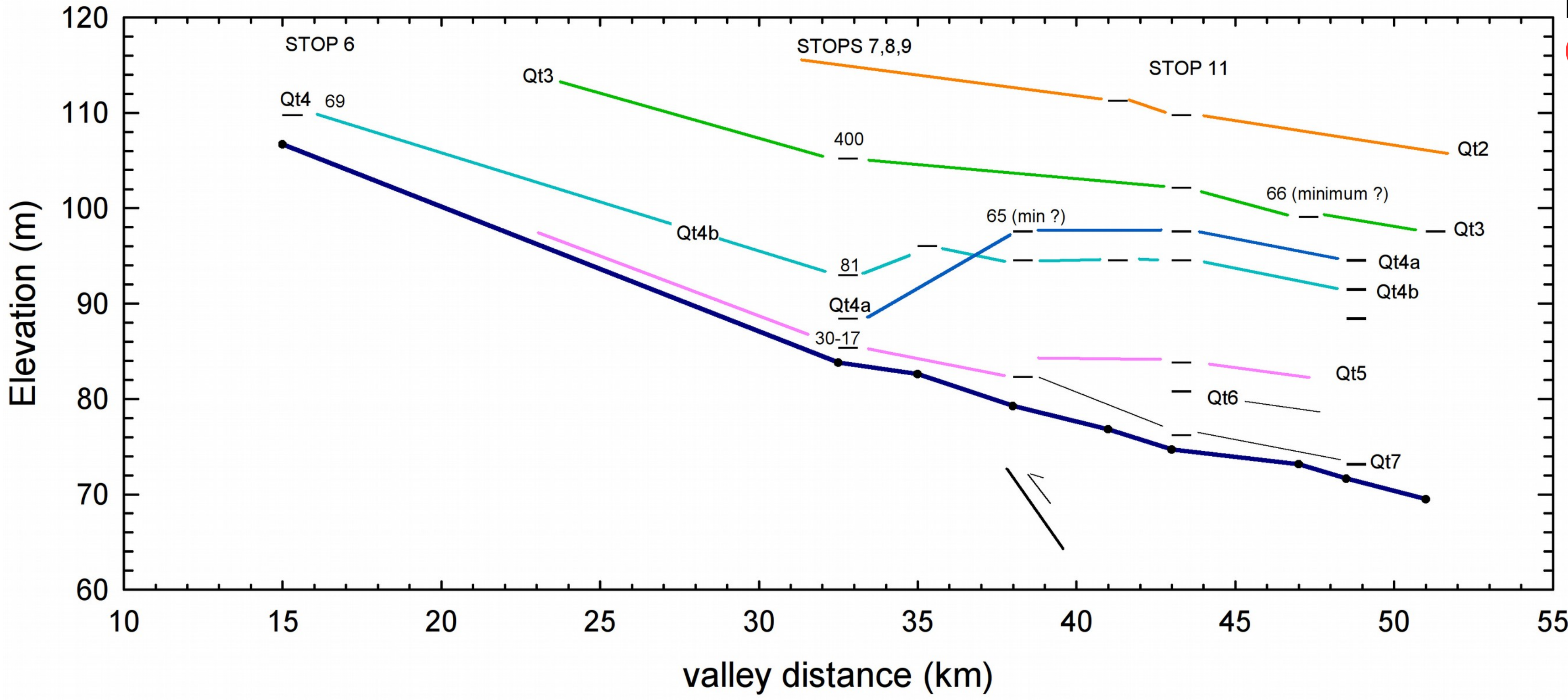


Sources of incision unsteadiness

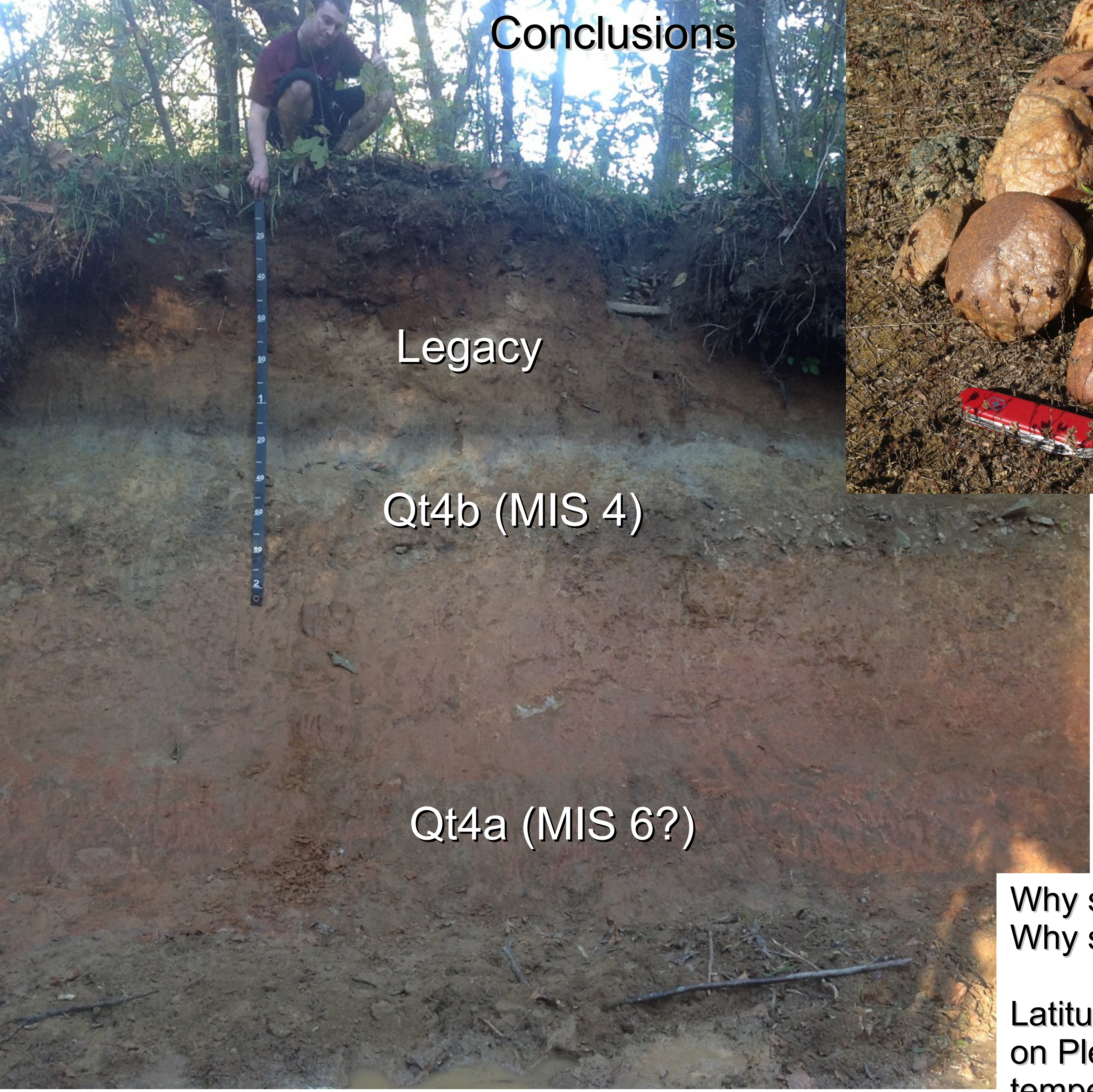
Climate

Base level fall

Complex response



Conclusions



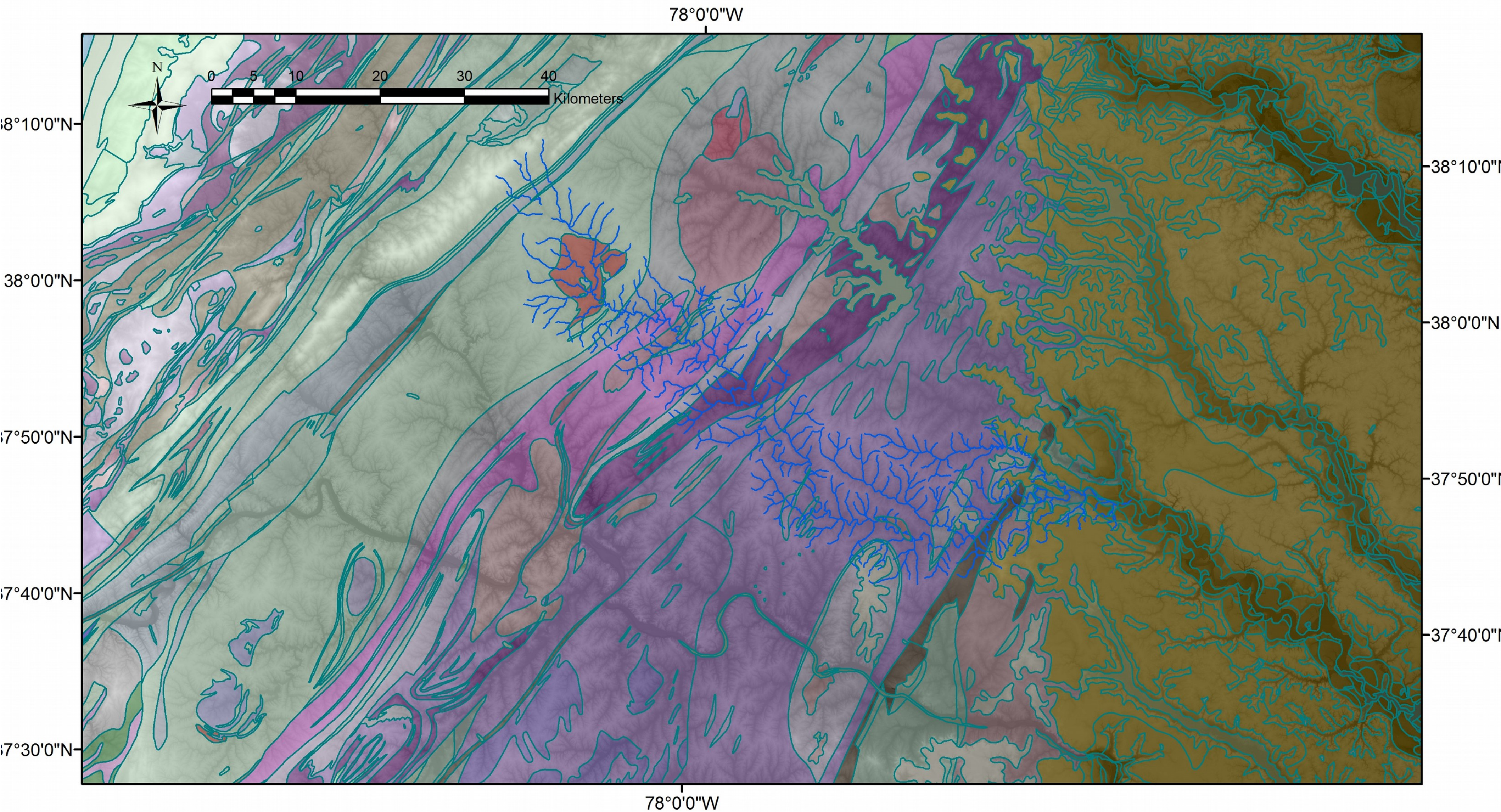
On the Qt4b strath

Sources of incision unsteadiness

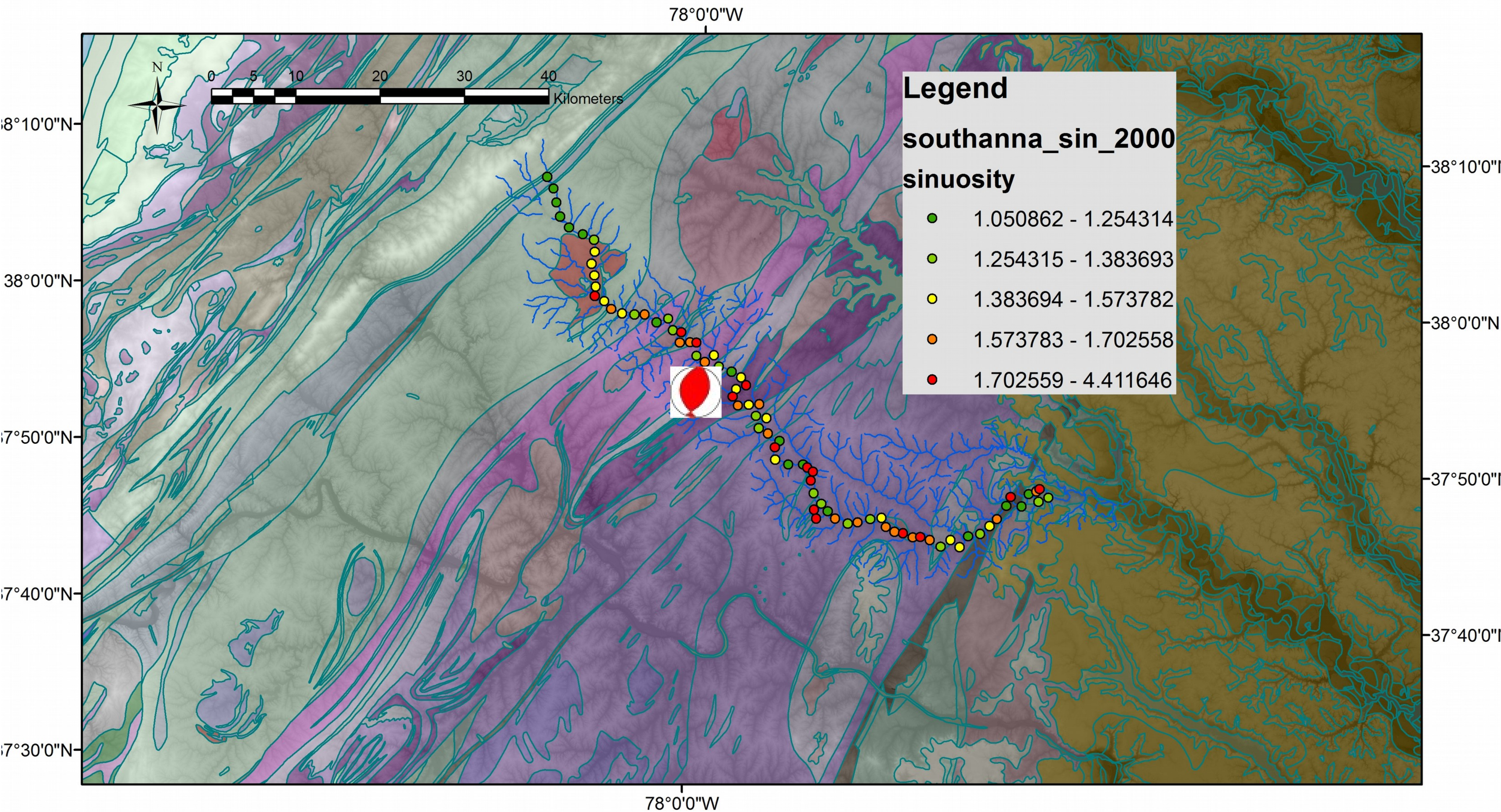
Climate
Base level fall
Complex response

Why so much MIS 4 sediment ?
Why so little LGM sediment ?

Latitudinal climate, impacts on Pleistocene temperature and moisture.



78°0'0"W
N
0 5 10 20 30 40
Kilometers
38°10'0"N
38°0'0"N
37°50'0"N
37°40'0"N
37°30'0"N
78°0'0"W



78°0'0"W
N
0
5
10
20
30
40
Kilometers
Legend
southanna_sin_2000
sinuosity
1.050862 - 1.254314
1.254315 - 1.383693
1.383694 - 1.573782
1.573783 - 1.702558
1.702559 - 4.411646
38°10'0"N
38°0'0"N
37°50'0"N
37°40'0"N
37°30'0"N
78°0'0"W