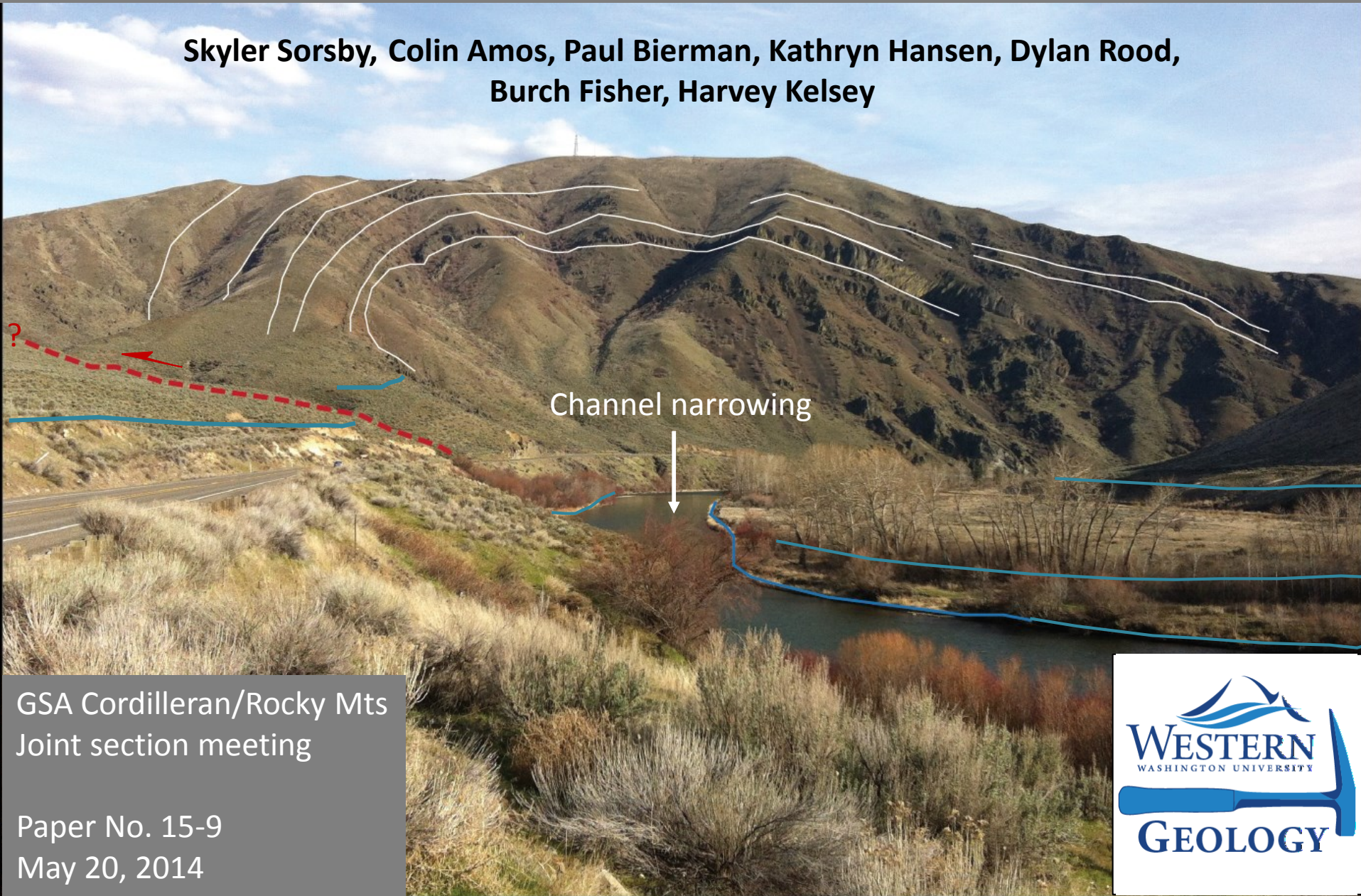


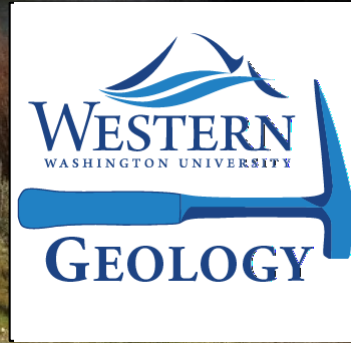
Uplift and incision of the Yakima River Canyon from channel planform mapping and cosmogenic $^{26}\text{Al}/^{10}\text{Be}$ isochron dating

Skyler Sorsby, Colin Amos, Paul Bierman, Kathryn Hansen, Dylan Rood,
Burch Fisher, Harvey Kelsey



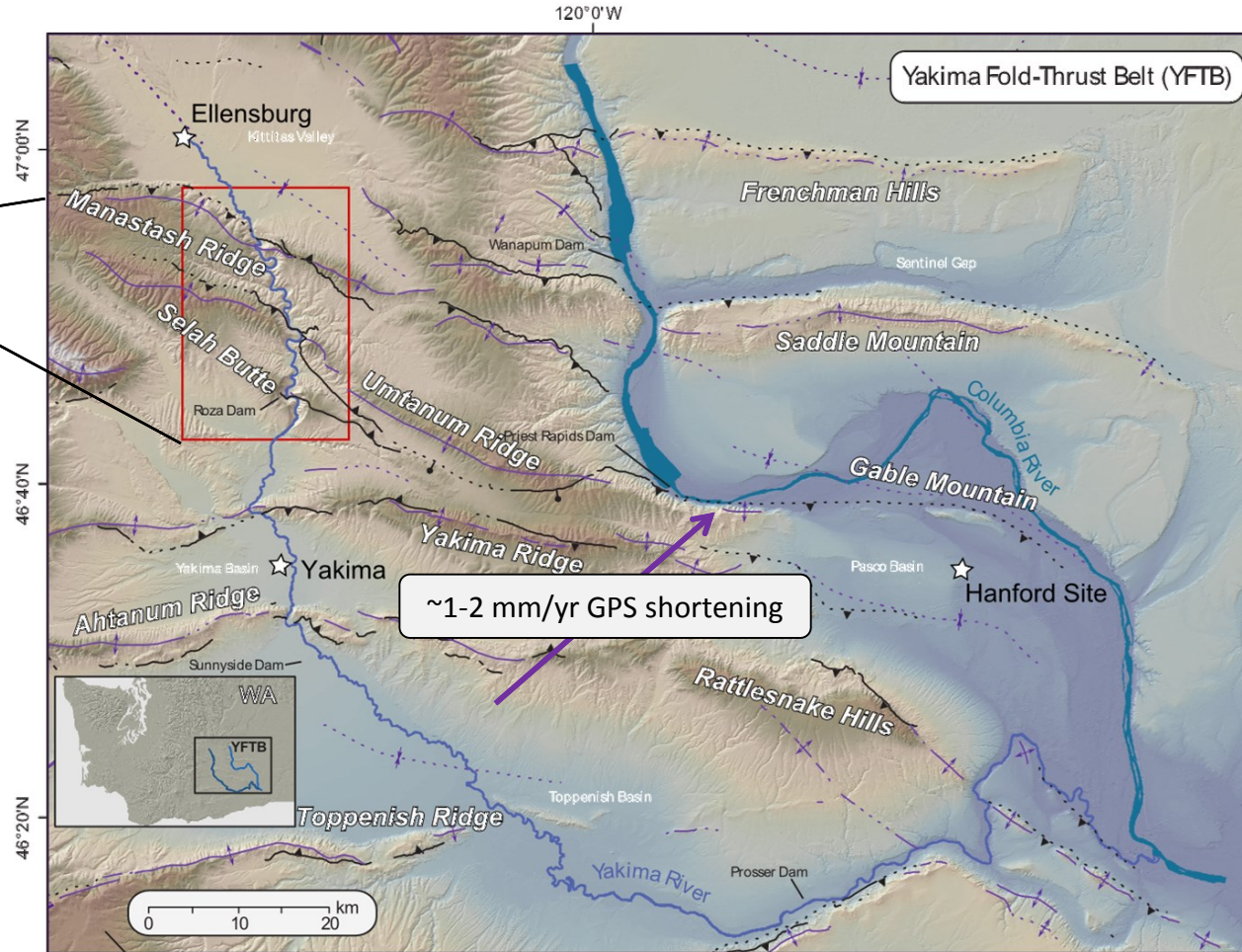
GSA Cordilleran/Rocky Mts
Joint section meeting

Paper No. 15-9
May 20, 2014



Tectonic setting

Study area



- NE-SW to E-W trending folds and thrust faults deforming miocene CRB
- Tight anticlinal ridges and broad synclinal valleys cross-cut by the Yakima River.
- GPS data predict ~1-2 mm/yr NE shortening (McCaffrey et al., 2013)

Fluvial analysis components

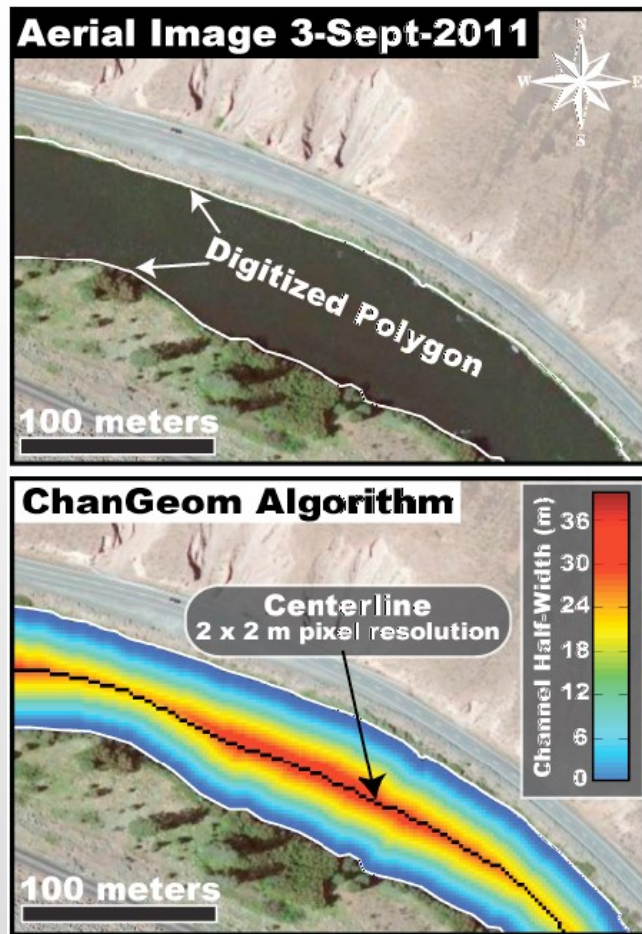
Methodology

1. High resolution channel width data from planform mapping with Matlab toolkit *Changeom* (Fisher et al., 2013, *Geomorphology*)
2. Terrace mapping and topographic analysis from lidar
3. CRN terrace dating

Key Questions

- Are Yakima structures currently active?
- Is Quaternary uplift differential or spatially uniform?
- How do the Yakima Canyon terraces correlate?
- What can CRN dating tell us about relative uplift rates?

Methods: Changeom



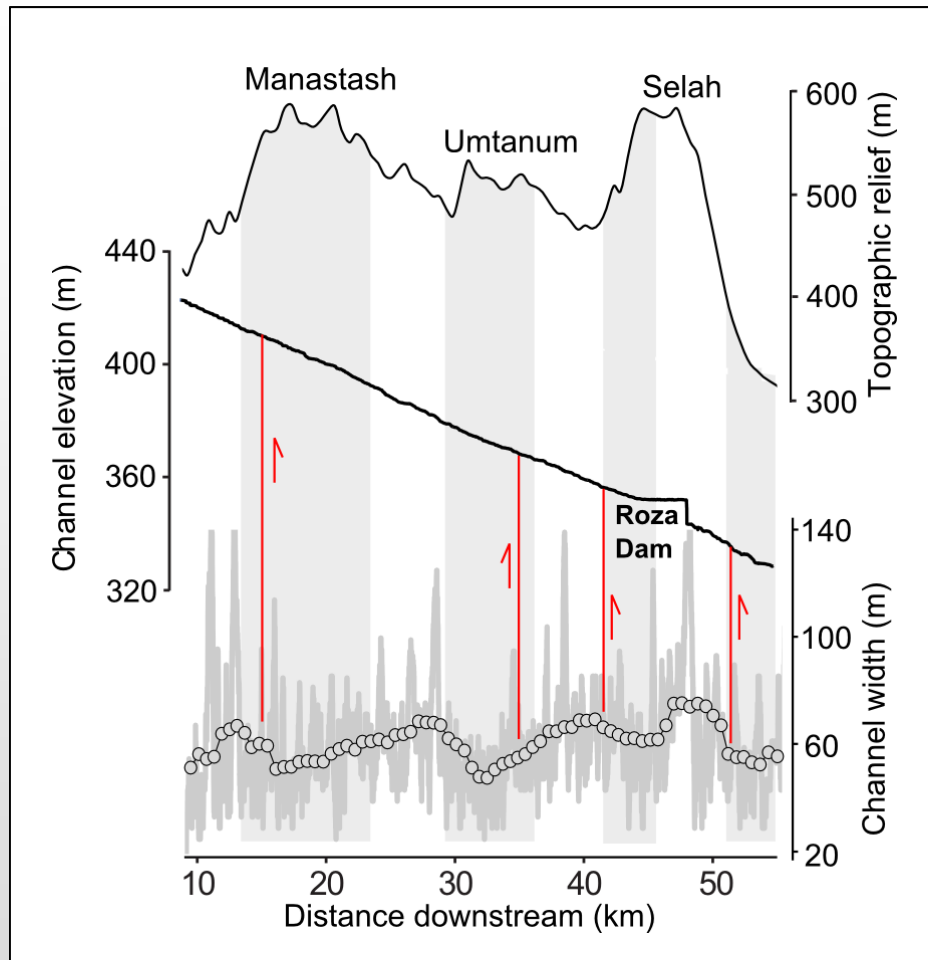
from Fisher et al. (2013),
Published in *Geomorphology*

Premise: Rivers may narrow across actively growing folds to gain incision power.

Methodology:

1. Channel planform digitized with high-resolution Google Earth imagery
2. Changeom creates channel centerline through binary thinning
3. Planform width is calculated from the centerline.

Changeom results

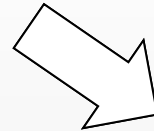
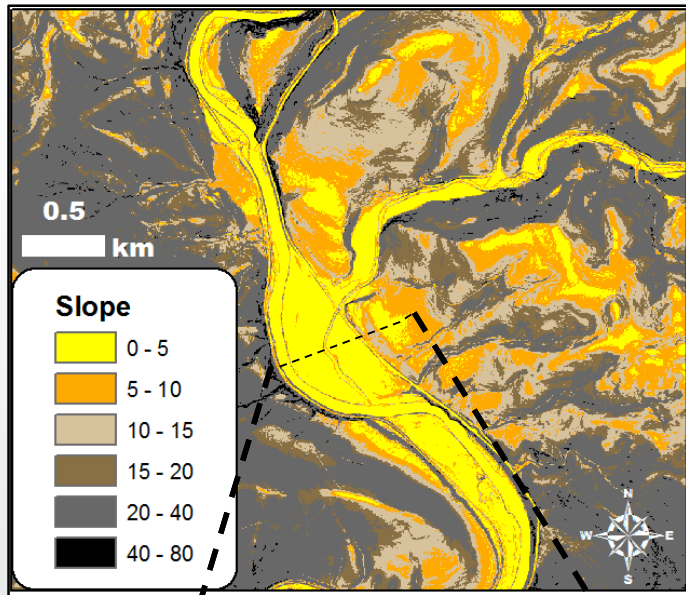


Channel width anomalies

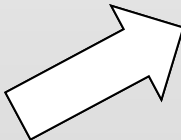
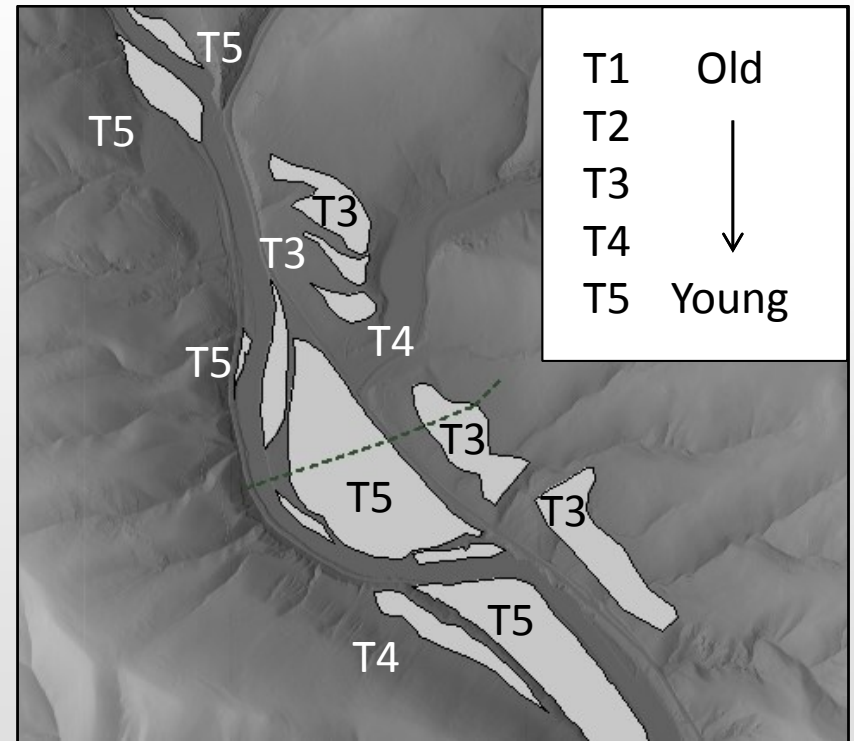
1. Distinct channel narrowing across Manastash, Umtanum, and Selah Butte structures
2. Spatial correlation with mapped faults
3. Substrate is uniform throughout the canyon (CRB)
4. Lidar survey reveals a lack of prominent knickpoints

Terrace mapping

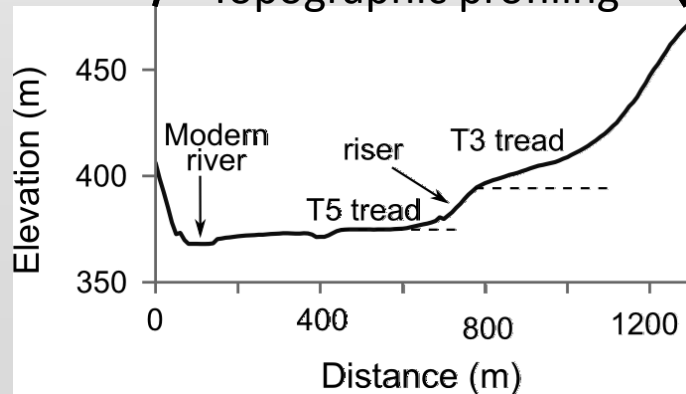
Slope map from lidar



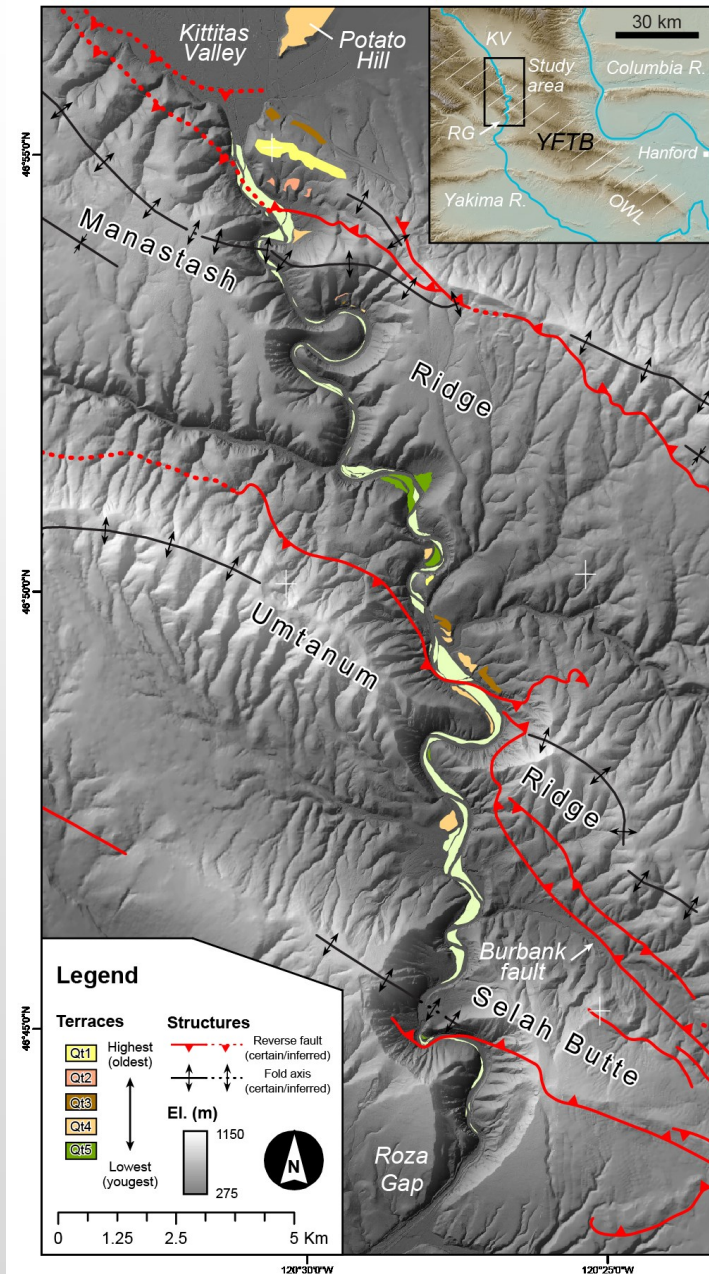
Preliminary terrace map



Topographic profiling



Results: mapping

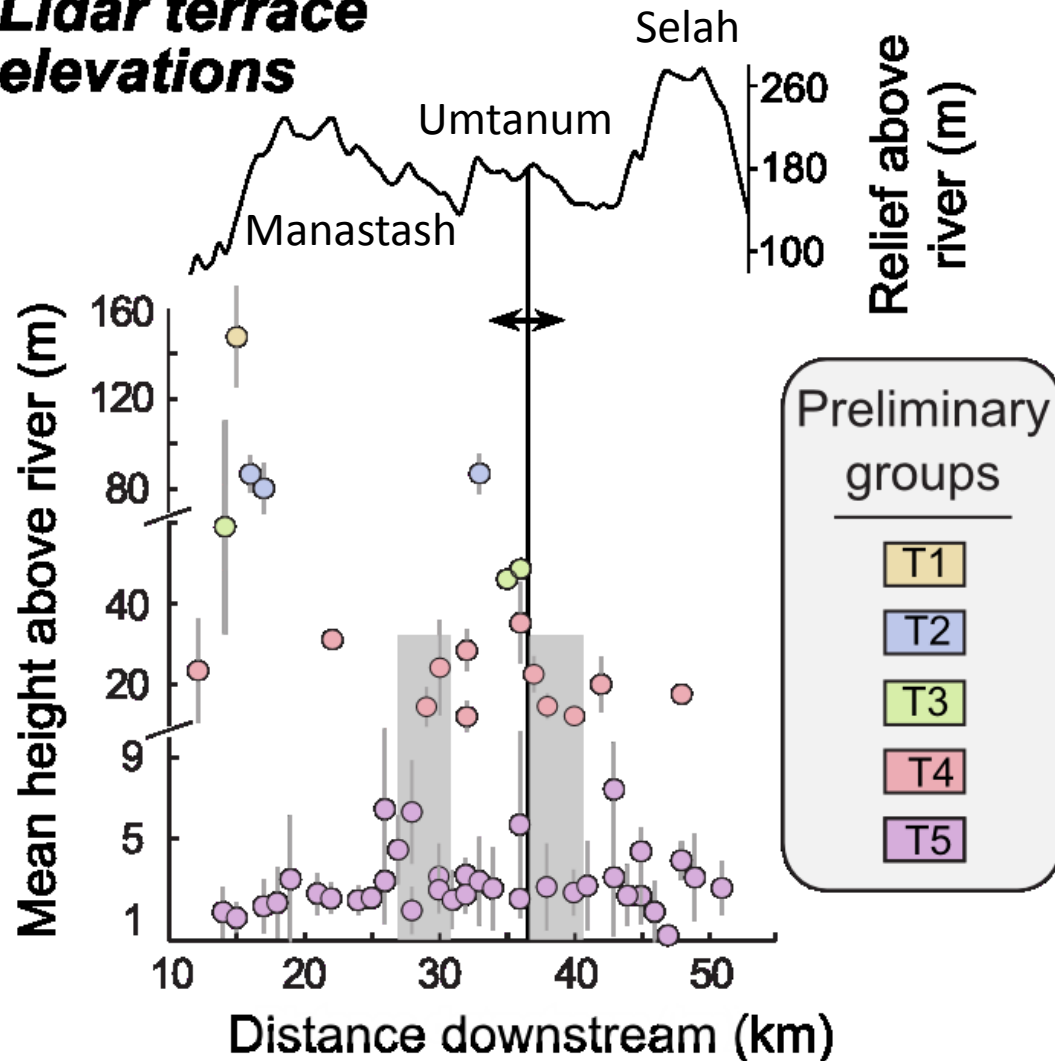


Terraces

1. Preliminary correlation based only on similar height above modern channel.
2. Treads are often mantled with alluvium or altered anthropogenically
3. Paleosurface remnants are patchy; downstream correlation is difficult from elevation data alone.

Results: mean elevation

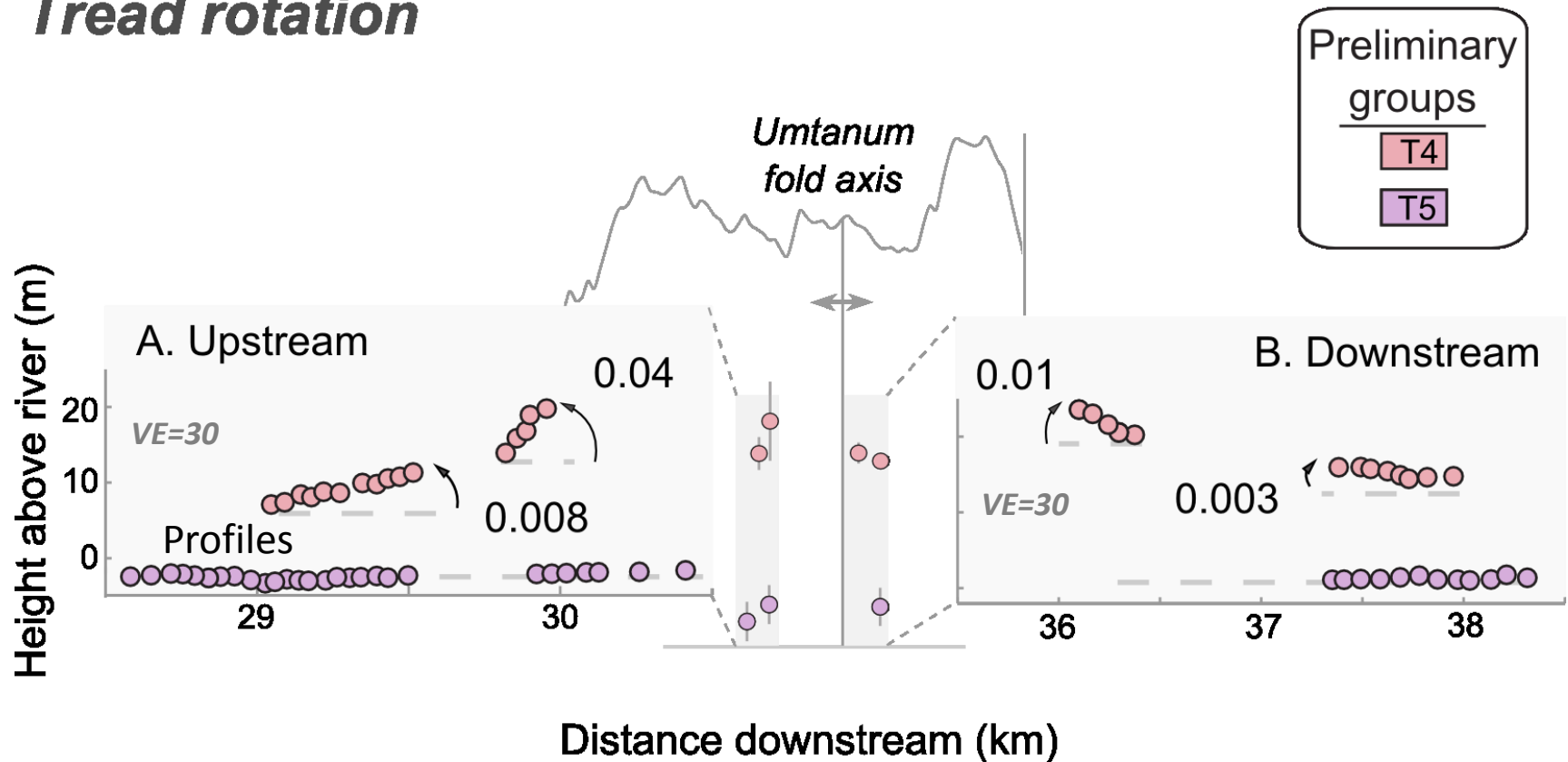
Lidar terrace elevations



1. Higher terraces proximal to Manastash and Umtanum folds.
2. Synclinal regions show greater clustering of lower terraces
3. Implications for differential uplift across the canyon

Results: Tread profiling

Tread rotation



Profiling of terrace treads reveals:

Increasing tilt as Umtanum fold axis is approached
Negligible deflection of modern surface

Methods: $^{26}\text{Al}/^{10}\text{Be}$ CRN dating



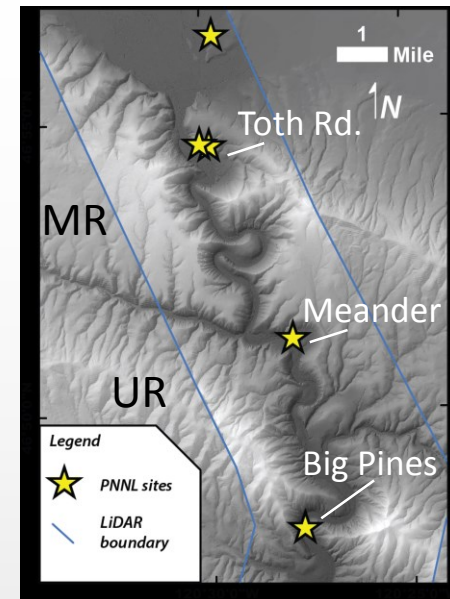
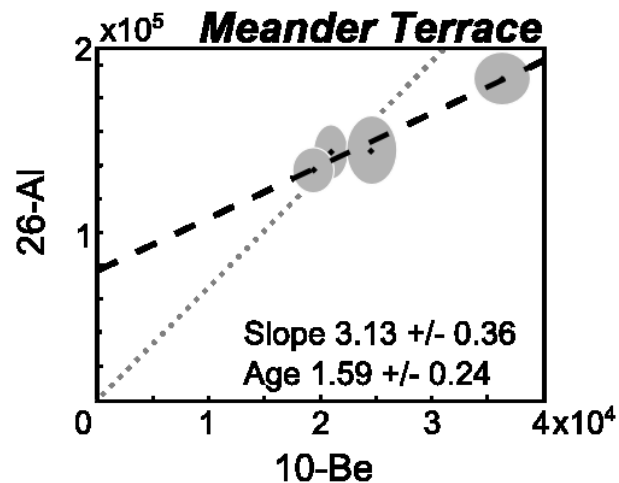
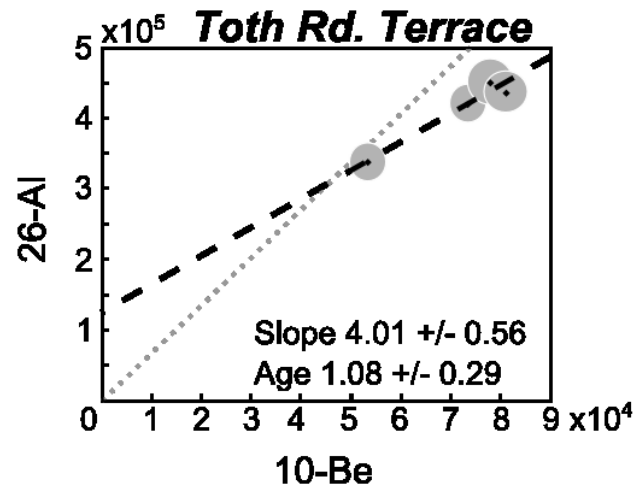
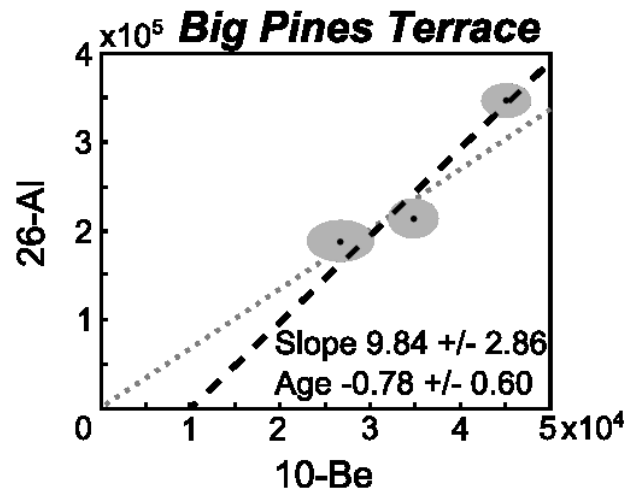
Isochron burial-Dating equation:
$$t_b = - \frac{\ln\left(\frac{R_M}{R_{init}}\right)}{(\lambda_{26} - \lambda_{10})}$$

(from Balco and Rovey 2008)

Sampling procedure

1. Quartz-rich river cobbles (likely source: Mt. Stuart Batholith)
2. Sampled >2 meters depth to ensure proper shielding from cosmic rays
3. Quartz cleaned and extracted at UVM
4. Analysis performed at the SUERC AMS lab in East Kilbride, Scotland.

$^{26}\text{Al}/^{10}\text{Be}$ isochron plots

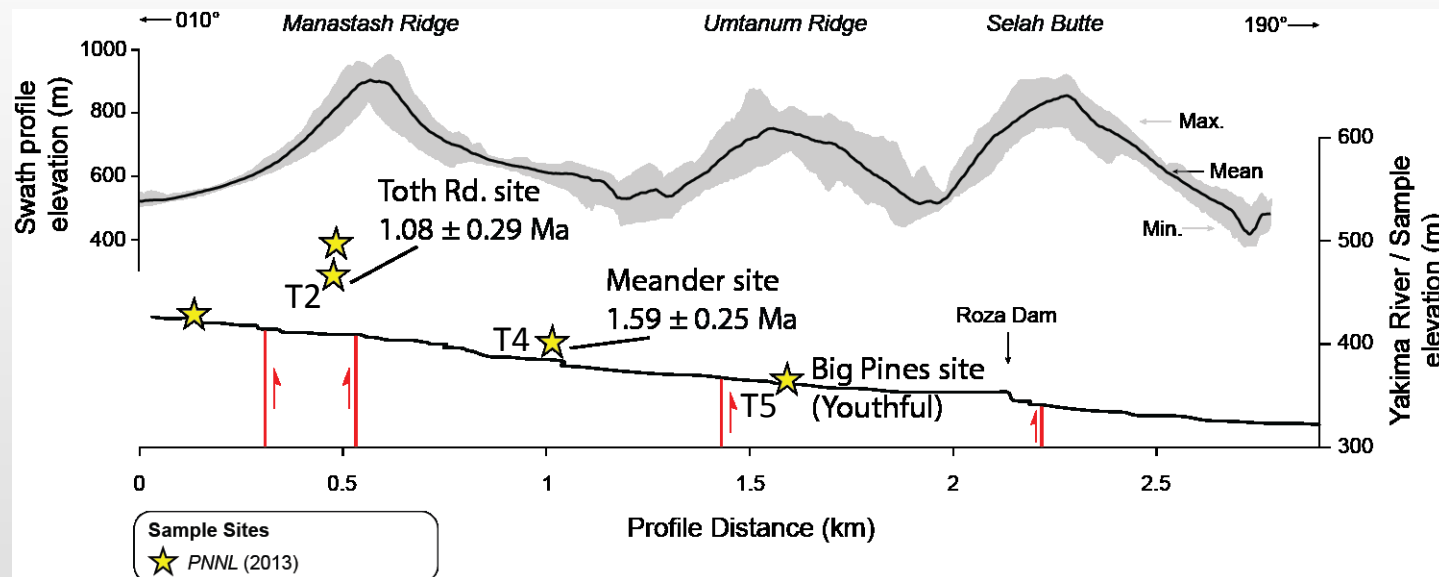


Lab results:

1. ^{26}Al and ^{10}Be concentrations are uniformly low (increases error to 1 std)
2. YK-03 (Big Pines terrace):
higher $^{26}\text{Al}/^{10}\text{Be}$ ratio—age is indistinguishable from modern.
3. YK-04 (Meander) and YK-05 (Toth Rd.):
lower $^{26}\text{Al}/^{10}\text{Be}$ ratio; ages are 1.59 ± 0.25 and 1.08 ± 0.29 Ma respectively.

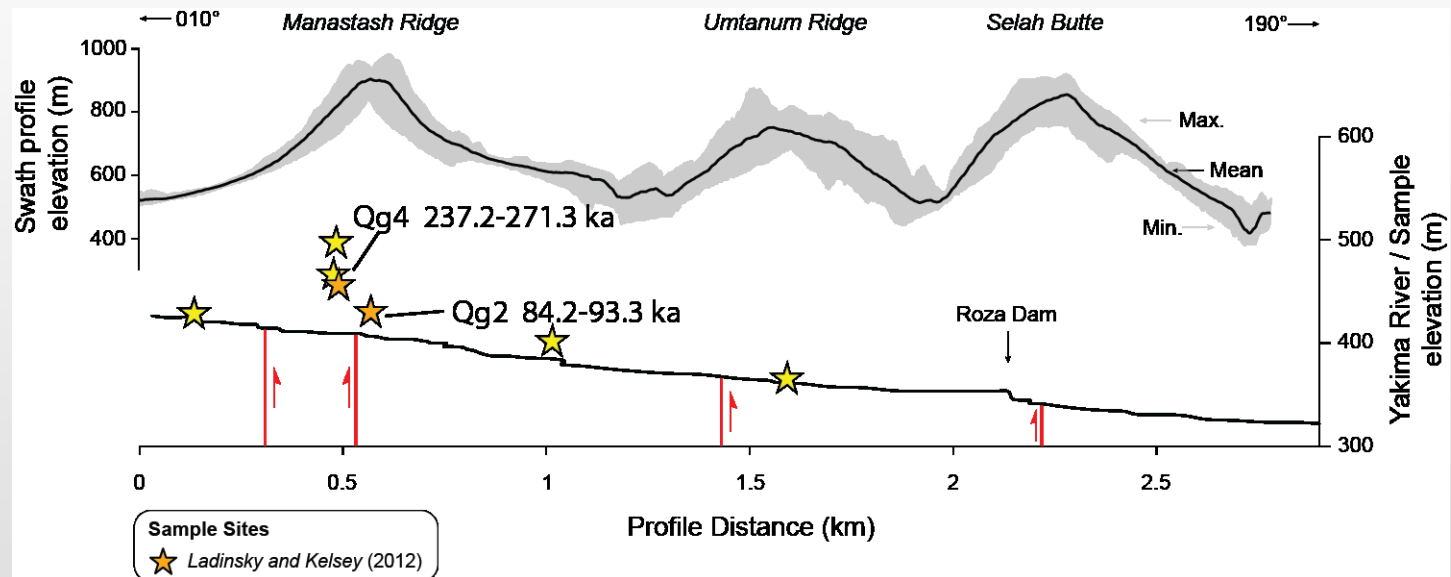
Results: CRN dates

Similar ages at considerably different elevations!



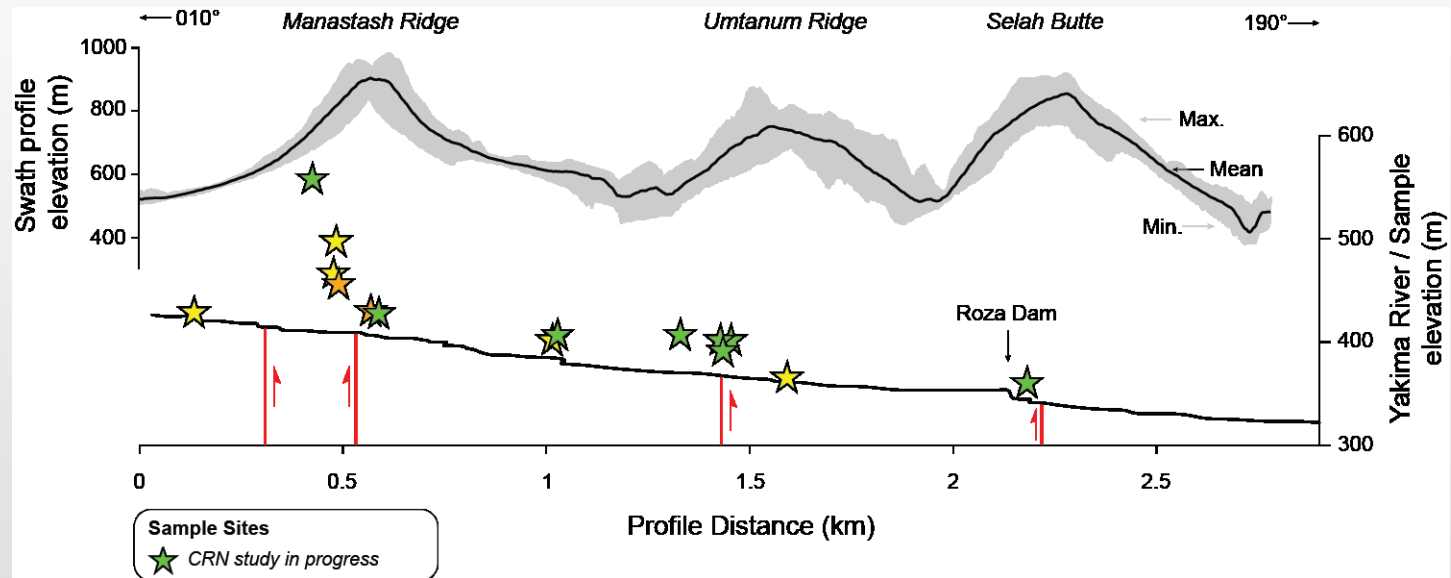
Site	CRN age (Ma)	Incision depth	Incision rate
Toth Rd.	1.08 ± 0.29	58 m	0.05 m/kyr (-0.002/+0.04)
Meander	1.59 ± 0.25	16 m	0.01 m/kyr (-0.004/+0.004)
Big Pines	~ modern	3 m	-----

Ladinsky and Kelsey dates



Site	CRN age (ka)	Incision depth	Inferred uplift rate
Qg2	84.2 – 93.3	15 m	0.16 – 0.18 m/kyr
Qg4	237.2 – 271.3	48 m	0.18 – 0.20 m/kyr

Terraces under current investigation



Adrian Bender (WWU MSc thesis) will date additional terraces (CRN burial) to assess differential incision rates in the Yakima River Canyon

Summary

1. Channel narrowing across Manastash, Umtanum, and Selah Butte indicates the presence and distribution of modest Quaternary deformation.
2. Evidence for Quaternary uplift of Umtanum seen in tilted terrace treads.
3. Evidence for the Quaternary uplift of Manastash from CRN dating (same ages high on an anticline, low on a syncline)
4. Further terrace dating will better constrain the timing, magnitude, and distribution of tectonic deformation in the Yakima Canyon.