USING LIDAR DEMS FOR GEOMORPHIC ASSESSMENT OF LAKE BONNEVILLE WAVE-CUT TERRACES AND POST-BONNEVILLE DISPLACEMENT ALONG THE WASATCH FAULT

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Figure A1 - South Salt Lake Terraces as observed from the top of Traverse Ridge in Draper, UT.

Figure A2 - South Salt Lake Terraces looking north along the Salt Lake City Segment of the Wasatch Fault.

Discussion Questions

-- Is slip unevenly distributed across the segment?

-- Why are terrace elevations higher at the fault segment boundaries and lower near its center?

Late Pleistocene and Holocene Multi-segment ruptures?

--Why is there variability within individual terrace clusters?

--Is terrace width a controlling factor of variability?

--Is there a control from fault block rotation and terrace proximities?

--How does the rotation of fault blocking effect terrace elevations along the fault?

--What role does isostatic rebound play with respect to terrace elevations and fault displacement?

--Are the terraces near segment boundaries effeced more by isostatic rebound verses those near the center?

B

Displacements, Slip Rates, and Uncertainties from Offset Bonneville High Stand Surfaces Along the South Salt Lake City Segment of the Wasatch Fault

Assumptions	*Measurement*	*Vertical Displacement*	*Fault Dip*[0]	*Net Fault Slip*	*Horizontal Fault Slip*	*Vertical Slip rate*[1]	*Horizontal Slip Rate*[1]	*Net Fault Slip Rate*[1]	*Geodetic Slip Rates*[2]
Local Fault Geometry	*min*	13.4 m	55°	16.3 m	9.4 m	***0.7 mm/yr***	0.5 mm/yr	***0.9 mm/yr***	VERTICAL
	max	27.8 m		33.9 m	19.4 m	***1.6 mm/yr***	1.1 mm/yr	***2.0 mm/yr***	1.7 ± 0.5 mm/yr
Down Dip Projection A[3]	*min*	6.9 m	25°	16.3 m	12.1 m	0.4 mm/yr	***0.8 mm/yr***	0.9 mm/yr	HORIZONTAL
	max	14.3 m		33.9 m	25.2 m	0.8 mmy/yr	***1.8 mm/yr***	2.0 mm/yr	2.9 ± 0.5 mm/yr
Down Dip Projection B[4]	*min*	13.4 m	25°	23.3 m	19.1 m	0.7 mm/yr	1.0 mm/yr	1.3 mm/yr	
	max	27.8 m		48.4 m	39.6 m	1.6 mm/yr	2.3 mm/yr	2.9 mm/yr	

0 – The' local fault geometry' fault dip corresponds to nearby measurements of the surface expression of the fault. The deeper dip loosely follows Velasco et al, 2010 and corresponds to analyses from Jewell and Bruhn, 2013.

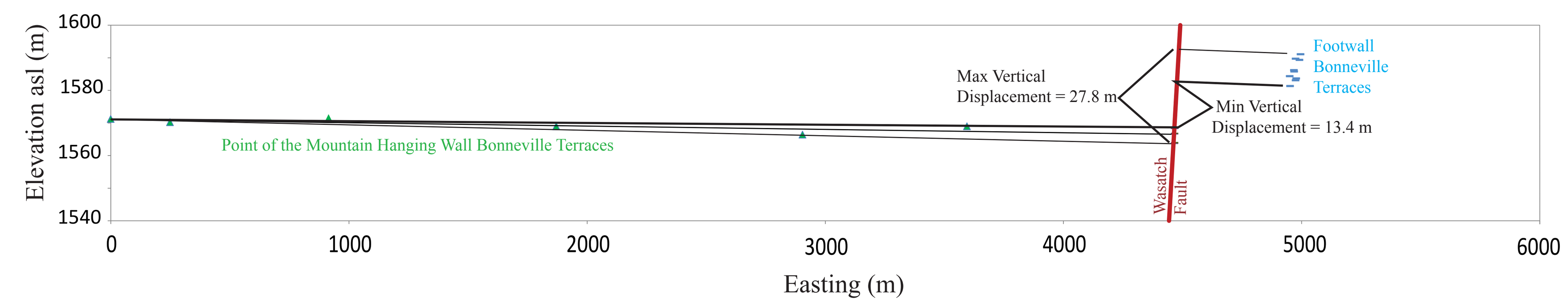
1 – Slip rates were calculated by converting the minimum and maximum displacements into millimeters and dividing by the estimated age of the Lake Bonneville high stand (17 – 18.5 ka: Benson et al., 2011)

2 – Comparison with geodectically-calculated Holocene slip rates from Friedrich et al., 2003 – horizontal rate calculated along a 30 degree effective fault dip.

3 – Down dip slip projection assuming net fault slip is transferred at a ratio of 1:1 along the fault to where the fault becomes shallow (~25 degrees; e.g., Velasco et al., 2010).

4 – Down dip slip projection assuming vertical displacement is transferred at a ratio of 1:1 (e.g., Jewell and Bruhn, 2013). This has the effect to increase the net fault slip rate as compared to surface estimates. This addition of fault slip might be justified if we presume that only ~70% of deep slip is transferred to the surface along the main Wasatch Fault trace.

C



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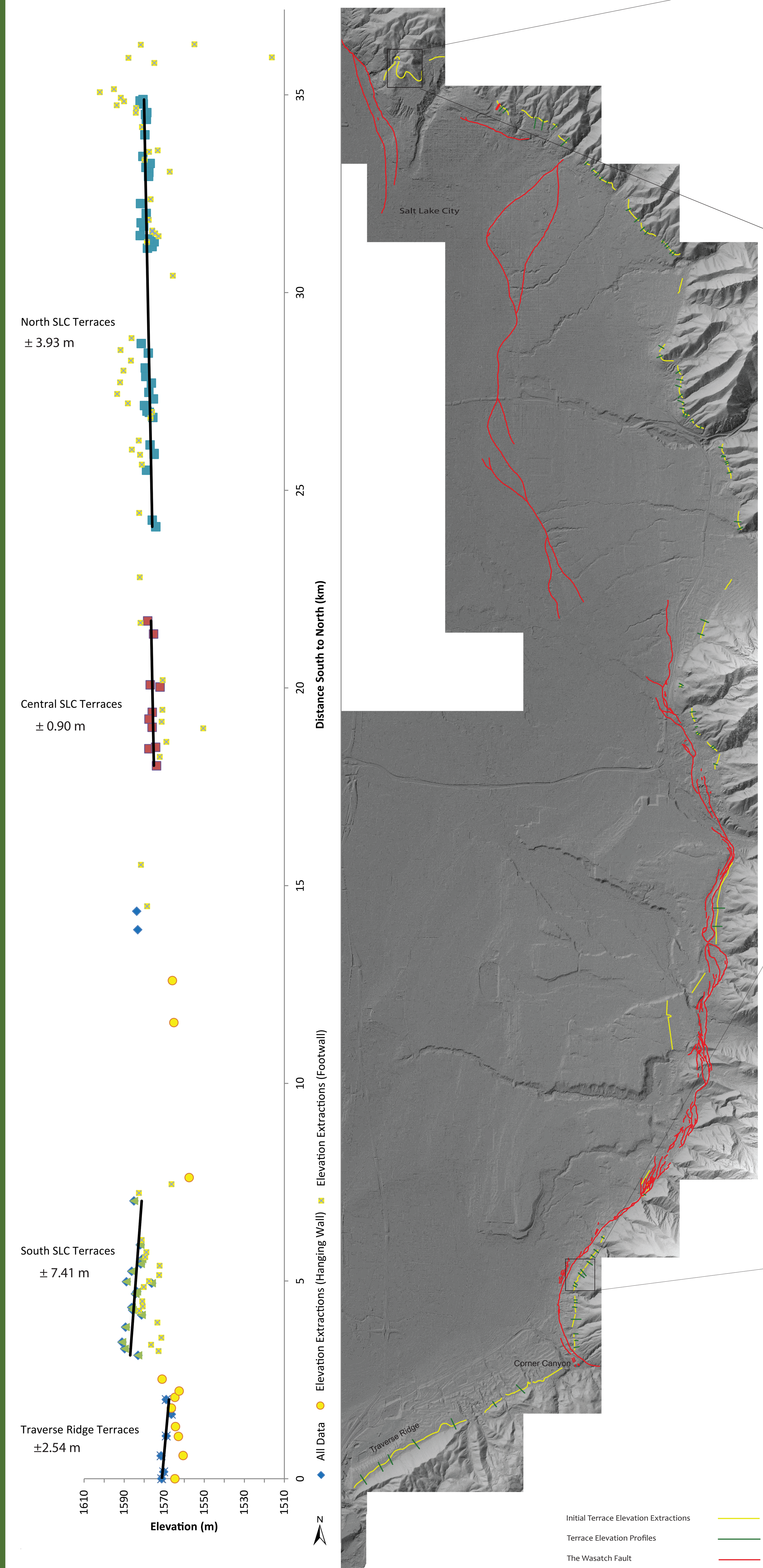
D

Variations in Bonneville Shoreline Elevations Along the Salt Lake Valley



LiDAR Extractions Reveal Pre-existing Mapping Errors

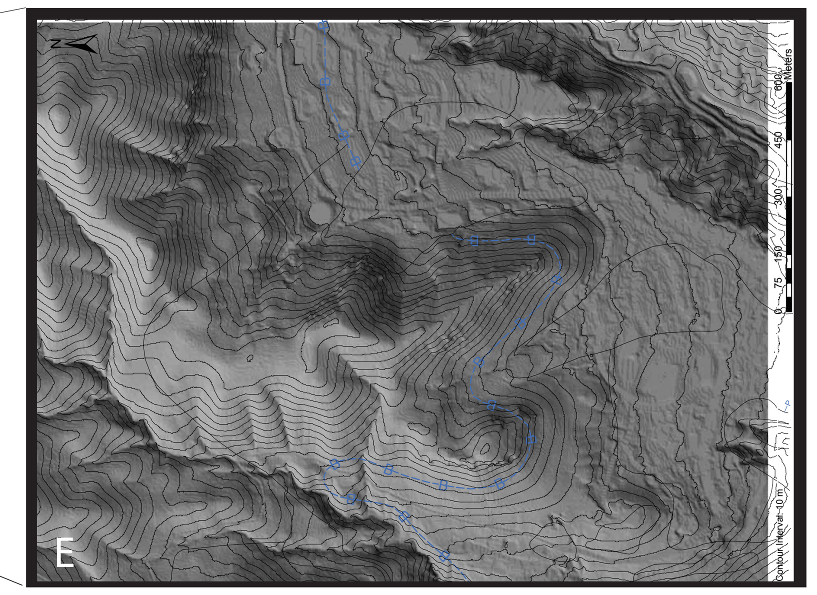


Figure E - Preexisting geologic maps were used in the initial terrace elevation extraction method (Figure D). Large standard deviations were pervasive within the data set which led to a close review of preexisting data used within GIS. The review yielded many insights with one being that contacts were poorly/inaccurately placed within the map, as can be seen with the shoreline(B) crossing multiple contour lines.

Formation and Modification of Wave-Cut Terraces

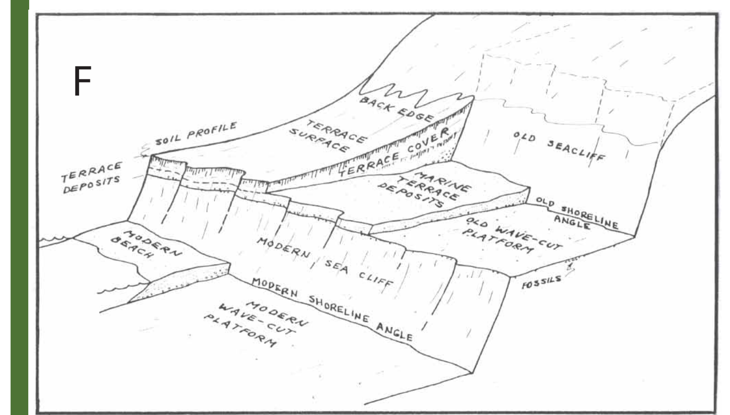


Figure F - Idealized cartoon showing the how wave action, followed by retreat (and sometimes deposition) forms terraces such as those of the Lake Bonneville high stands.

Figure G - The large standard deviations found within in the initial terrace elevation extraction method led us to use a high precision field profile extraction method using RTK-GPS, yielding profile elevations with cm-scale accuracy. With this in mind we compared elevations extracted from the RTK-GPS with those extracted using a LiDAR profile extraction tool within GIS. Elevations were very comparable, validating the GIS elevation profile extraction method for a complete analysis of The Bonneville Shoreline. This method was infinitely faster.

Mapping ~18,000 Years of Landscape Modification reveals few geomorphically-simple surfaces for inner-edge profile extractions.

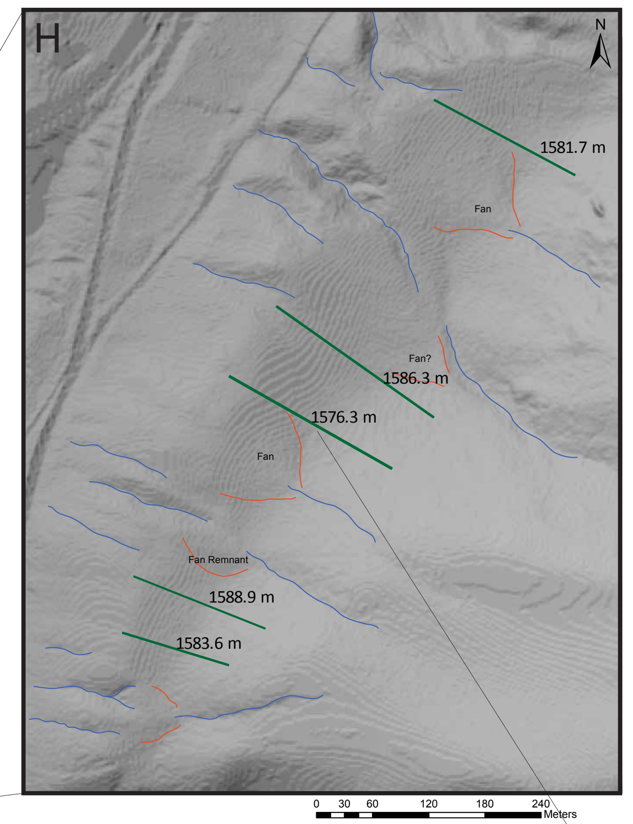


Figure H - Since the retreat of Lake Bonneville, erosional processes have continued to modify these geomorphic-markers. Careful mapping shows that multiple fan surfaces as well as channels are prevalent which inflate or deflate the actual terrace elevation as can be seen in the variability of terrace inner-edge elevations .

Figure I - A cross-sectional profile looking down the strike(NE) of the profile extraction line which is marked green in Figure H. Once an ideal site (minimal modification other than colluvial draping) is located, an approximate original surface form can be determined by finding the part of the surface with constant slope on the present day terraces and hillslopes. These are then projected to an intersection point which we presume represents the approximate original elevation of the terrace's inner-edge.