Application of LiDAR data to constraining a late Pleistocene slip rate and vertical deformation of the Northern San Andreas Fault, Fort Ross to Mendocino, California: Collaborative research between Arizona State University and the U.S. Geological Survey.

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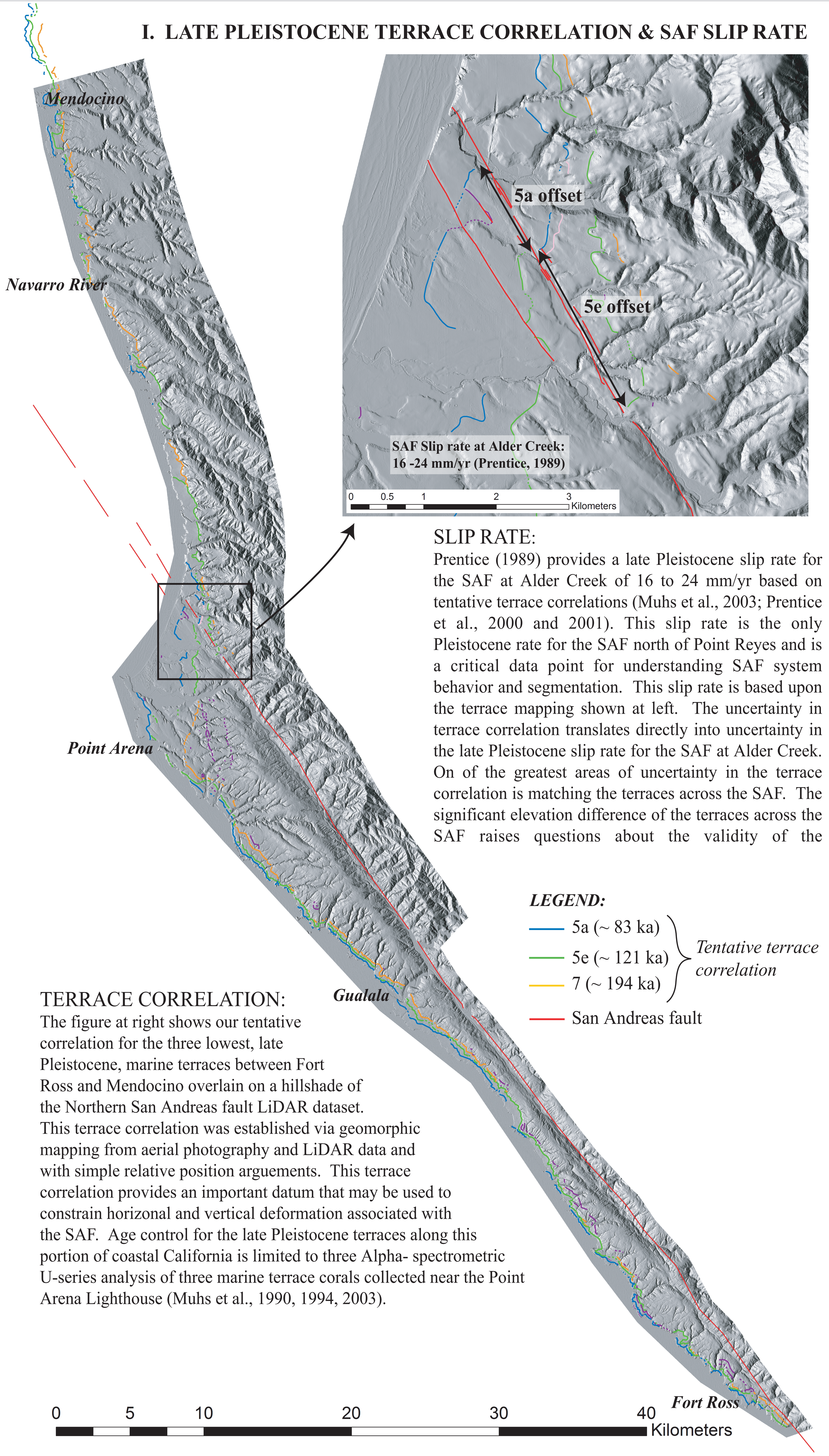
I. LATE PLEISTOCENE TERRACE CORRELATION & SAF SLIP RATE



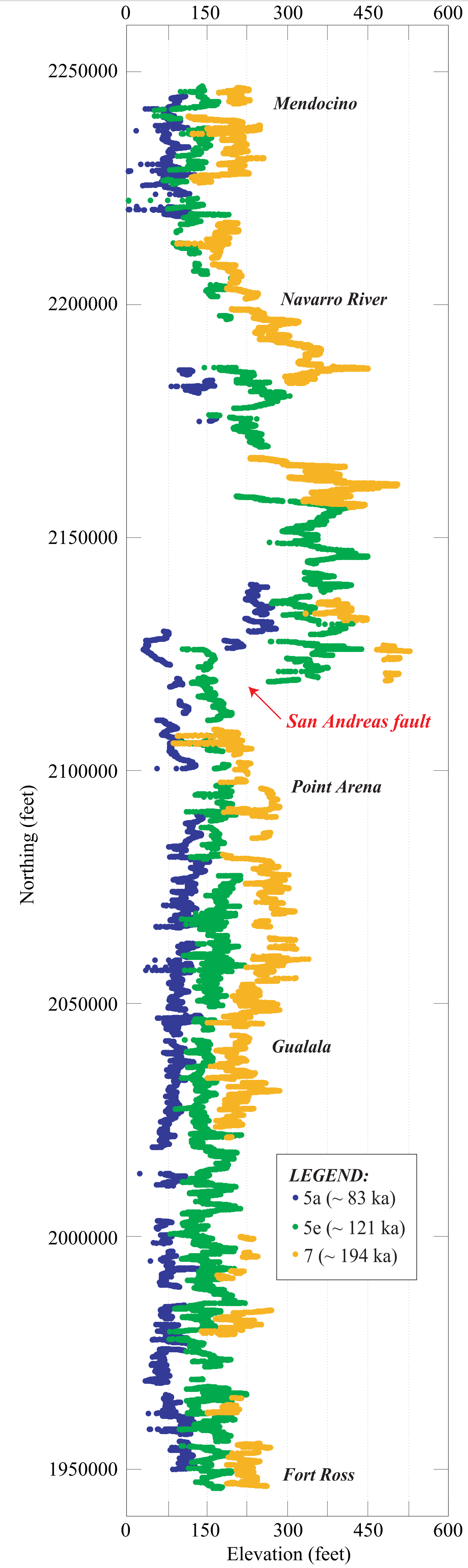
SLIP RATE:

Prentice (1989) provides a late Pleistocene slip rate for the SAF at Alder Creek of 16 to 24 mm/yr based on tentative terrace correlations (Muhs et al., 2003; Prentice et al., 2000 and 2001). This slip rate is the only Pleistocene rate for the SAF north of Point Reyes and is a critical data point for understanding SAF system behavior and segmentation. This slip rate is based upon the terrace mapping shown at left. The uncertainty in terrace correlation translates directly into uncertainty in the late Pleistocene slip rate for the SAF at Alder Creek. On of the greatest areas of uncertainty in the terrace correlation is matching the terraces across the SAF. The significant elevation difference of the terraces across the SAF raises questions about the validity of the

TERRACE CORRELATION:

The figure at right shows our tentative correlation for the three lowest, late Pleistocene, marine terraces between Fort Ross and Mendocino overlain on a hillshade of the Northern San Andreas fault LiDAR dataset. This terrace correlation was established via geomorphic mapping from aerial photography and LiDAR data and with simple relative position arguements. This terrace correlation provides an important datum that may be used to constrain horizonal and vertical deformation associated with the SAF. Age control for the late Pleistocene terraces along this portion of coastal California is limited to three Alpha- spectrometric U-series analysis of three marine terrace corals collected near the Point Arena Lighthouse (Muhs et al., 1990, 1994, 2003).

This material is based upon research supported by the National Earthquake Hazards Reduction Program under Grant No. 06HQGR0032



II. LATE PLEISTOCENE MARINE TERRACE ELEVATIONS

INTRODUCTION:

The plot at left shows the inner edge elevations of the three lowest marine terraces between Fort Ross and Mendocino. See part I (left panel of the poster) for the terrace mapping. These terraces provide an excellent marker for the study of spatial and temporal variation in off-SAF deformation. The plot shows elevation vs. the northing component of the California State Plane coordinate system.

METHODS:

To determine the elevation of the marine terrace inner edges throughout the study area,we began with the inner edge mapping shown in part I (left panel of this poster). Next, the elevation of the inner edges were extracted from the NSAF LiDAR DEM. Finally, the elevations for the three lowest terraces were exported to Matlab and the plot shown at left was produced.

OBSERVATIONS:

- Inner edge elevations for the three lowest marine terraces are significantly higher immediately to the north of the SAF, then they are at greater distances north or south of the SAF.
- The area of elevated marine terraces is bound by the SAF on the south and the Navarro River to the north. This bulge in the terraces is asymmetric with the highest elevations immediately to the north of the SAF. Terrace elevations decreasing gradually to the north until they level off just north of the Navarro.
- Terrace elevations at the southern and northern ends of the study area are similar.
- Warping of the terraces between Gualala and Point Areana may indicate increased uplift rates in this area as well.
- The scatter in elevations for a given terrace inner edge is largely due to variation in the thickness of sediment / colluvium overlying the bedrock terrace platform. Other factors contributing to the elevation scatter include digitizing errors and locations where the inner edge mapping crosses drainages incised into the terrace.
- Plots such as this one provide an indication of potential errors in the terrace correlation and should help to guide us to refine the terrace mapping and correlation

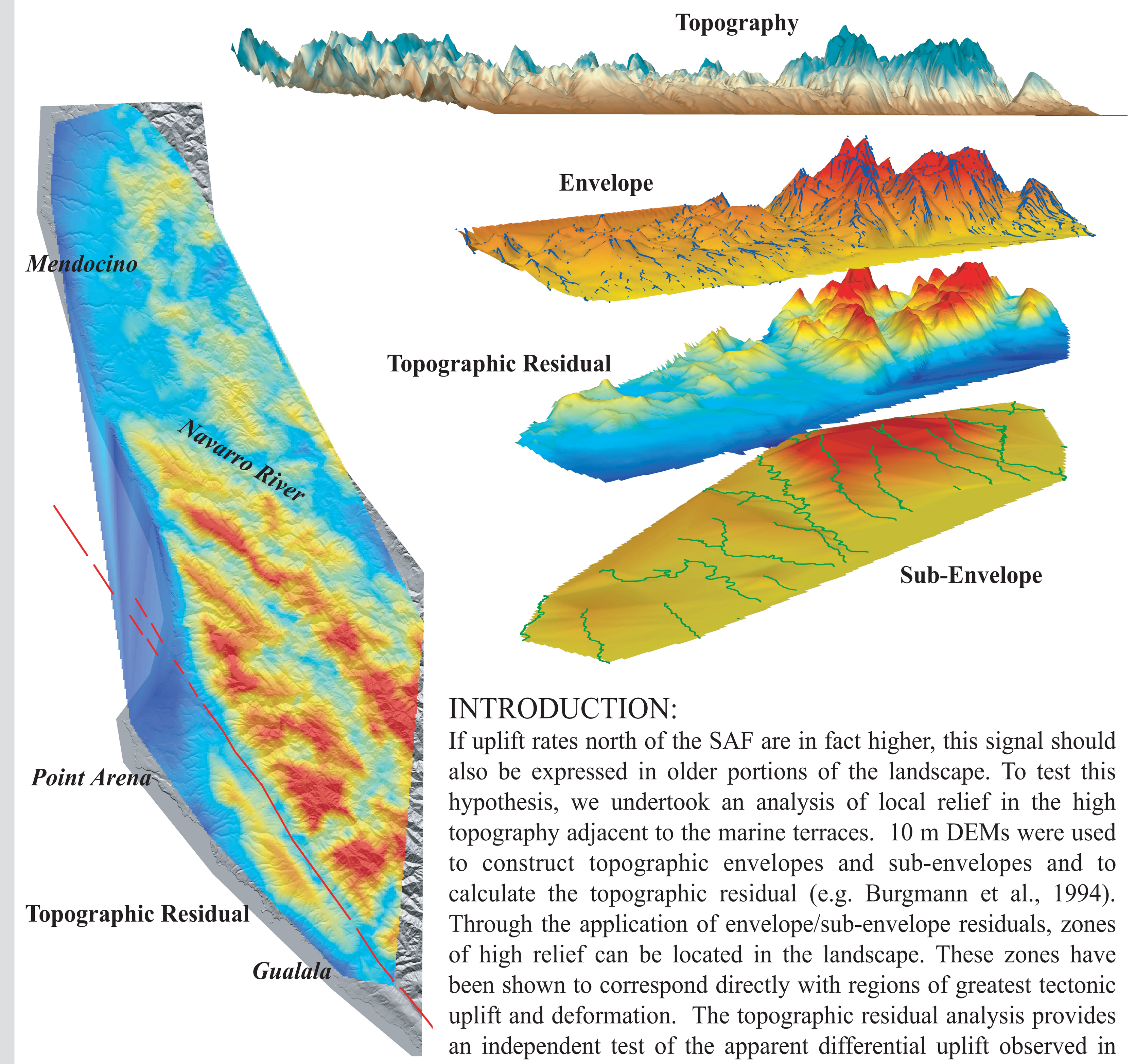
UPLIFT RATE ESTIMATES:

Assuming the terrace correlation is correct, tentative late Pleistocene uplift rates vary by a factor of three in the study area:

Immediately north of the SAF: ~.75 - .95 mm/yr

South of Gualala/near Mendocino: ~.28 - .38 mm/yr

III. ENVELOPE / SUB-ENVELOPE TOPOGRAPHIC RESIDUAL ANALYSIS



INTRODUCTION:

If uplift rates north of the SAF are in fact higher, this signal should also be expressed in older portions of the landscape. To test this hypothesis, we undertook an analysis of local relief in the high topography adjacent to the marine terraces. 10 m DEMs were used to construct topographic envelopes and sub-envelopes and to calculate the topographic residual (e.g. Burgmann et al., 1994). Through the application of envelope/sub-envelope residuals, zones of high relief can be located in the landscape. These zones have been shown to correspond directly with regions of greatest tectonic uplift and deformation. The topographic residual analysis provides an independent test of the apparent differential uplift observed in the marine terraces and may be an opportunity to constrain SAF fault geometry and/or segmentation.

OBSERVATIONS:

- The greatest local topographic relief is immediately north of the SAF. This zone of high relief extends northward to the Navarro and east to the edge of the study area. Intuitively, the area of greatest local relief corresponds directly with the area of highest topography in the study area.
- The geometry of the high relief region suggests uplift adjacent to the SAF and tilting of the range up and away from the fault. The hinge for this tilting appears to be just to the north of the Navarro.
- The orientation of the Navarro is almost perfectly coincident with the margin of the high relief zone, one may hypothesize that the location of the Navarro has been migrating northward with time as the topography to the south gains elevation, forcing the drainage to slip to the north.
- Boundary element modeling is currently ongoing to evaluate the SAF geometry and slip history necessary to generate the observed deformation pattern.

IV. CONCLUSIONS:

- The spatial correlation between high topographic residuals and increased terrace elevations suggests that the the observation of elevated inner edge elevations are due to higher uplift rates north of the SAF and not due to errors in the marine terrace correlation.
- Given the above, it is possible to infer that the 16-24 mm/yr slip rate given by Prentice (1989) for the SAF at Alder Creek is valid.
- Assuming the terrace correlation is correct, uplift rates just north of the SAF are ~.75 - .95 mm/yr. Rates away from the SAF in the study area are approximately three times slower at ~.28 - .38 mm/yr
- Additional work is necessary to examine possible Pliocene marine terrace units (e.g. Higgins, 1960) in the higher topography that may be used to constrain vertical deformation rates over a longer temporal range. Boundary element modeling of the observed deformation pattern will help to constrain SAF geometry.