Sierra Nevada - Great Valley Foothills, 36N to 37N:
He apatite thermochronometry along a new horizontal transect

Frank Sousa, Jason Saleeby, Ken Farley

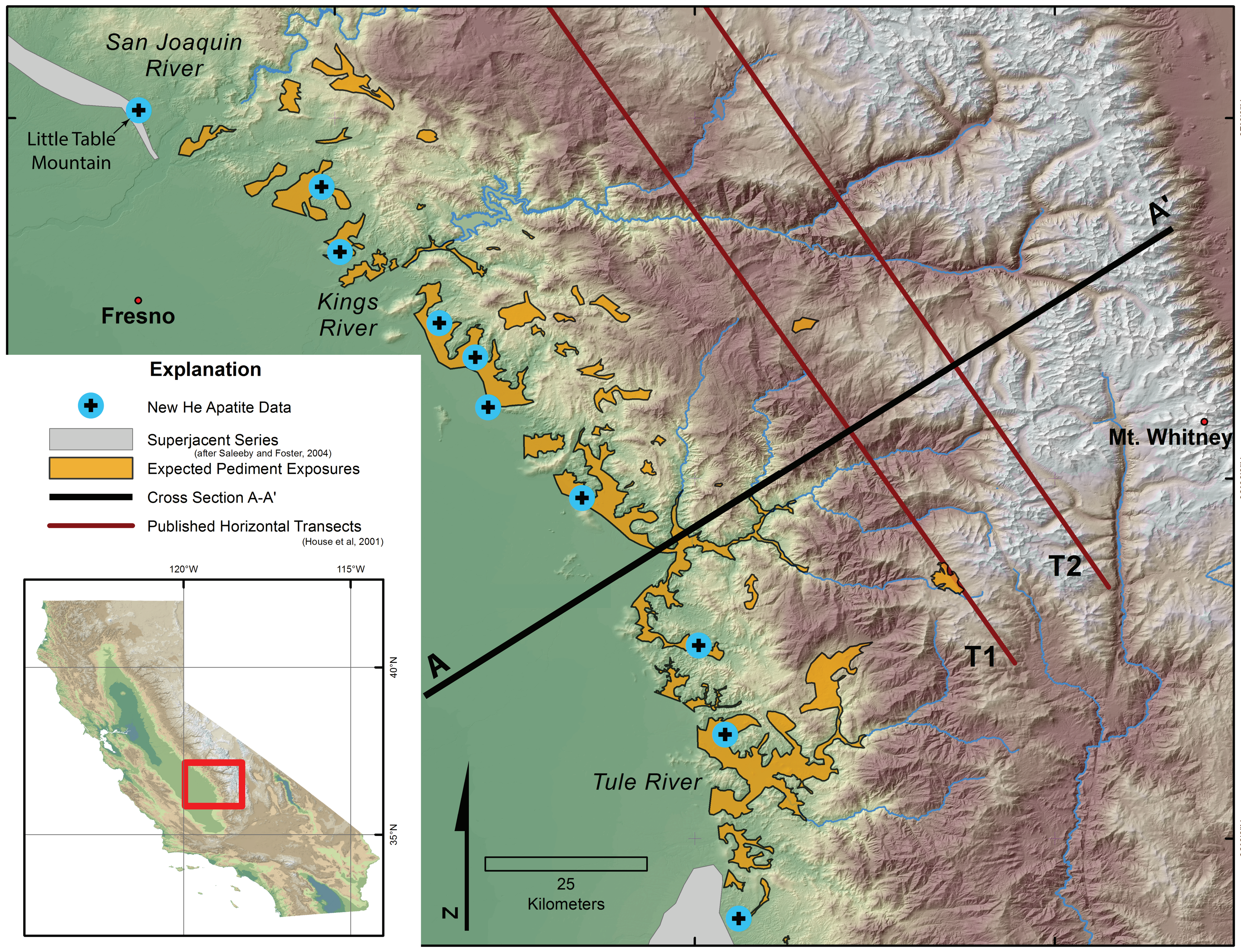


Figure 1. Location map of study area. Blue/black crosses show sample sites along the new He apatite horizontal transect. Deep red T1 and T2 lines show approximate locations of published He apatite horizontal transects (House et al., 2001). Expected pediment exposures are mapped in yellow based on preliminary field reconnaissance and DEM analysis using a 7° slope mask (Twidale, 1981) derived from 1/3 arc-second National Elevation Data Set (USGS). Cross section A-A' is shown in figure 5.

Abstract:

Preliminary field reconnaissance indicates that a bedrock pediment landscape exposed locally between 36N and 37N along the western Sierra Nevada Foothills ramp spans these latitudes in lateral continuity. New apatite helium thermochronologic data from this landscape suggest a Late Cretaceous rapid exhumation event. Stratigraphic relations and geomorphology support the hypothesis that this bedrock landscape is pre-Eocene and was preserved through Cenozoic time under shallow burial by Eocene strata which have subsequently been removed between 36N and 37N.

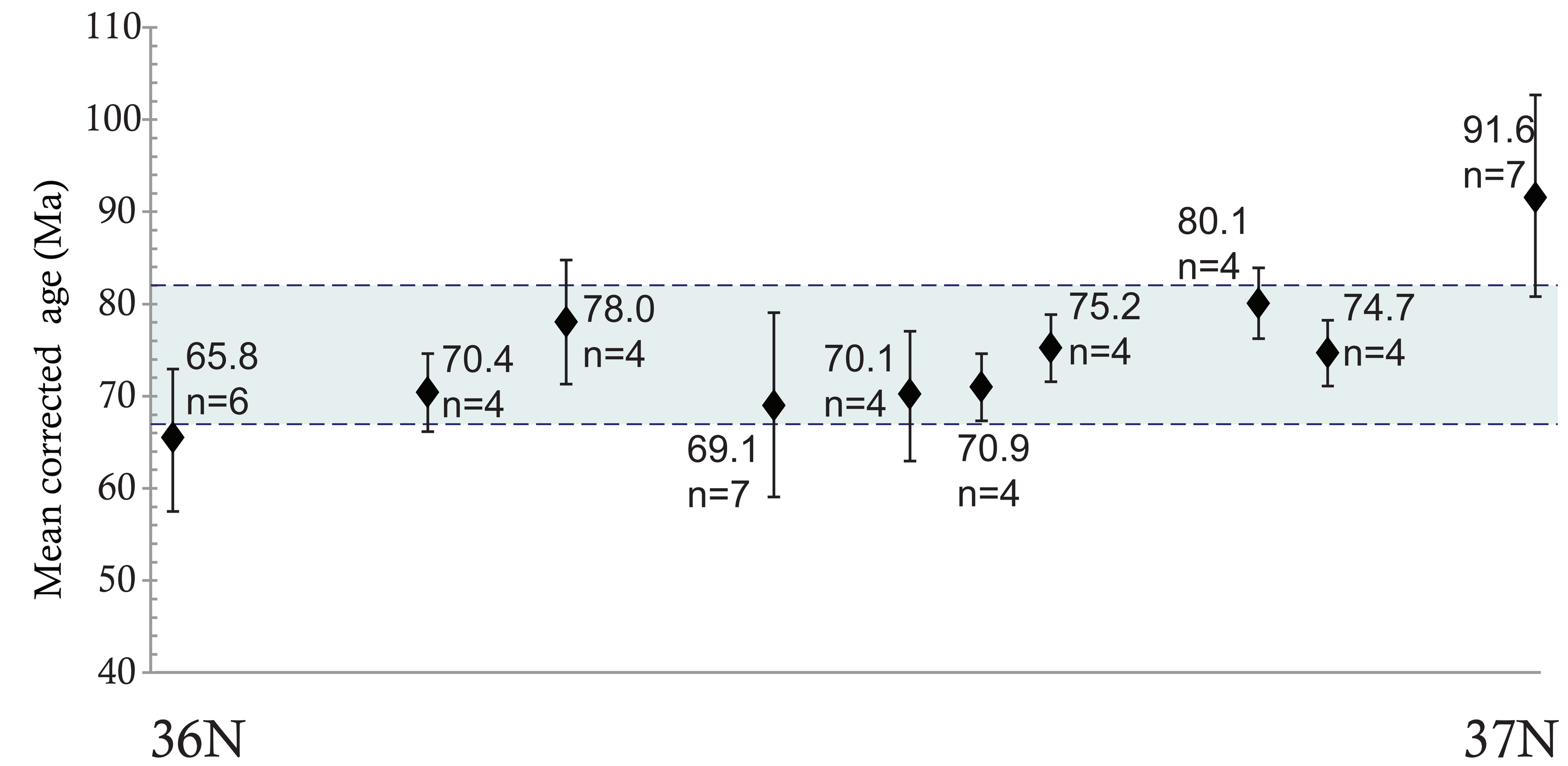
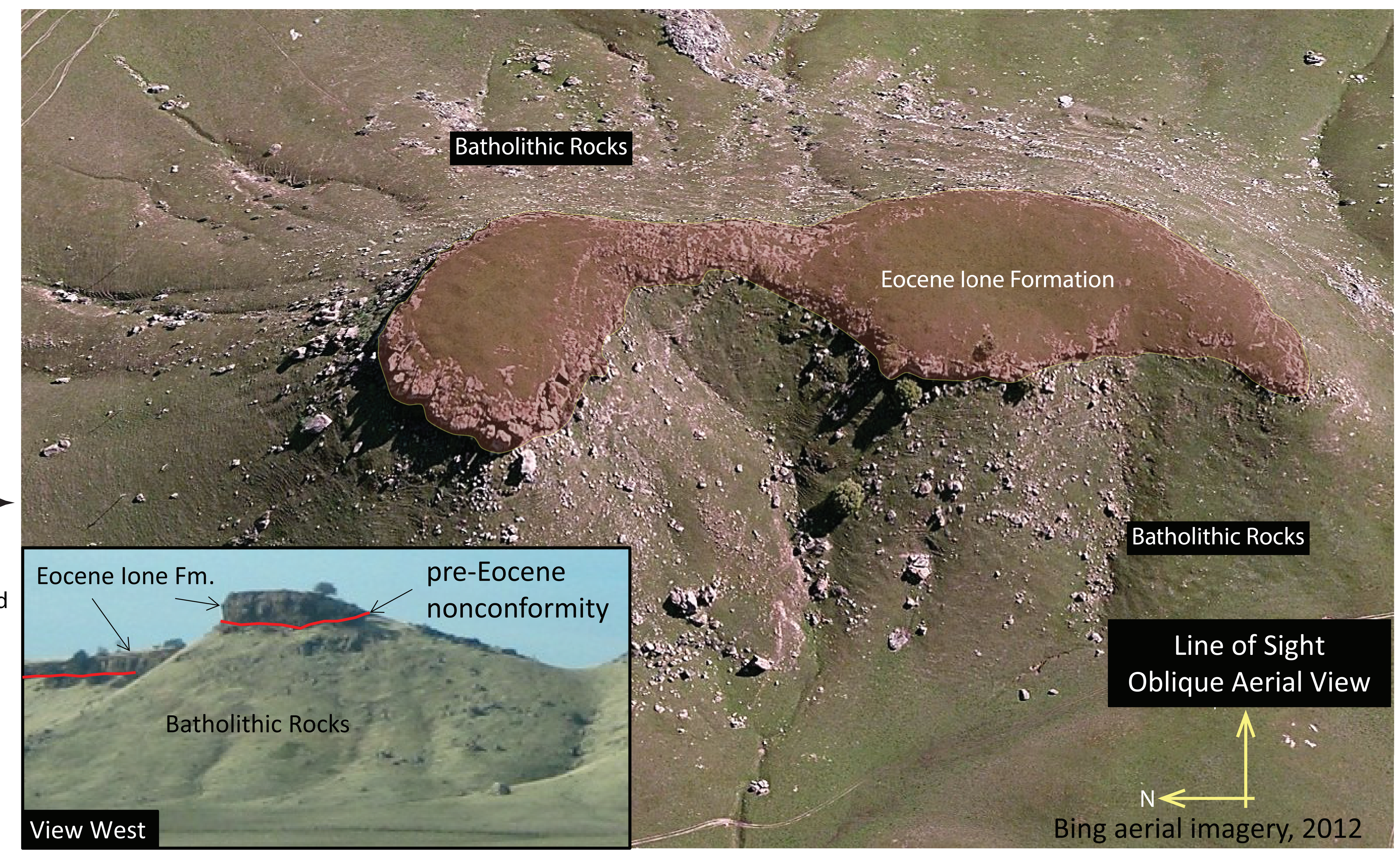


Figure 2. Mean corrected He apatite ages from new horizontal transect. Errors are 1σ amongst replicate single grain analyses from each rock sample. Gray shaded area is inferred 75 ± 8 Ma isochronal swath. n= number of single grain analyses for each sample.

Figure 3. Annotated photographs of Little Table Mountain, CA showing southernmost Eocene Ione formation nonconformably overlying the bedrock pediment landscape investigated in this study.



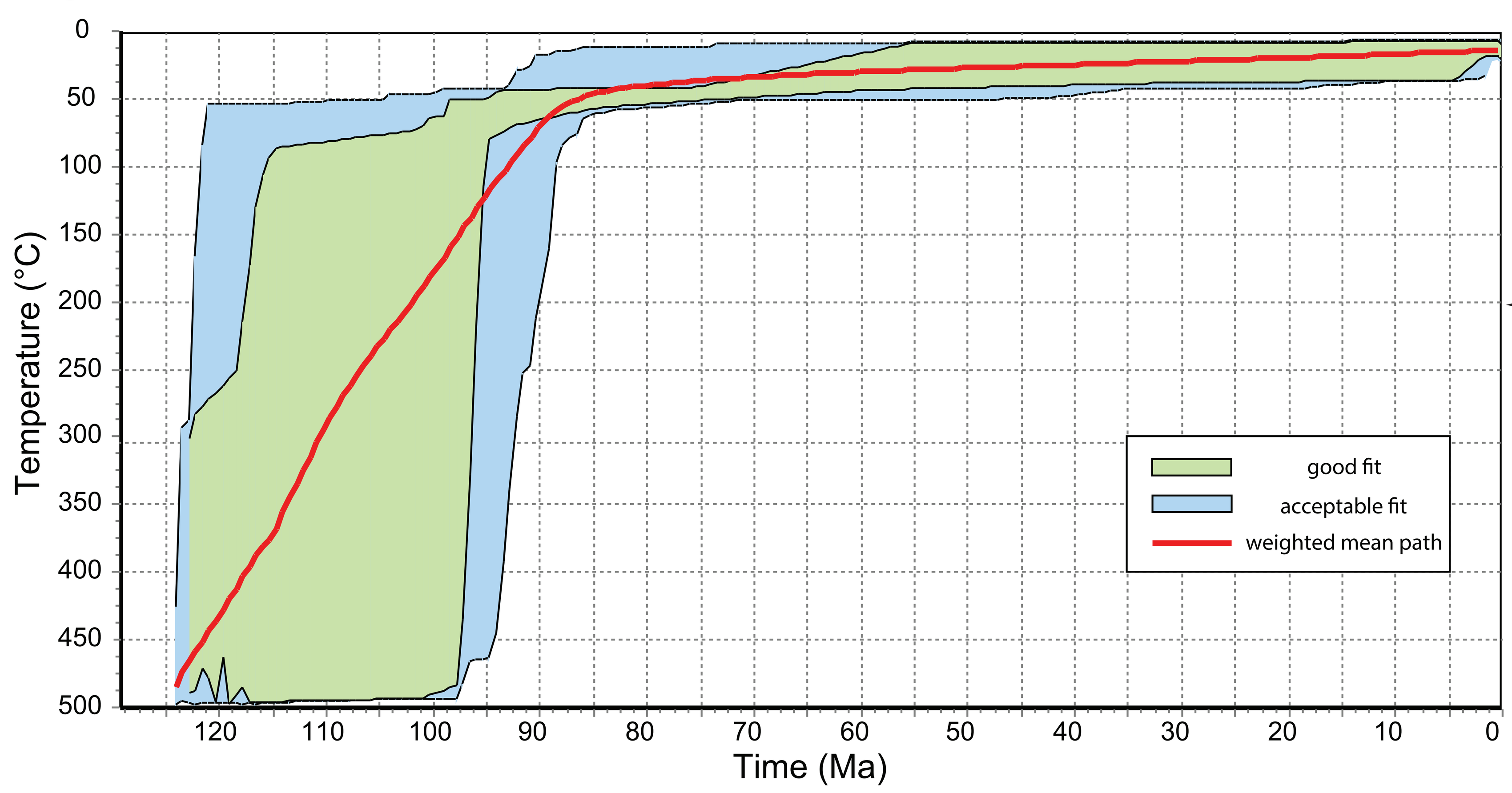


Figure 4. Inverse model result using HeFTy 1.7.5 and U-Th-Sm/He data from 5 individual apatite grains from granitoid rock sample taken ~50 m below the Eocene Ione nonconformity at Little Table Mountain (see figures 1, 3).

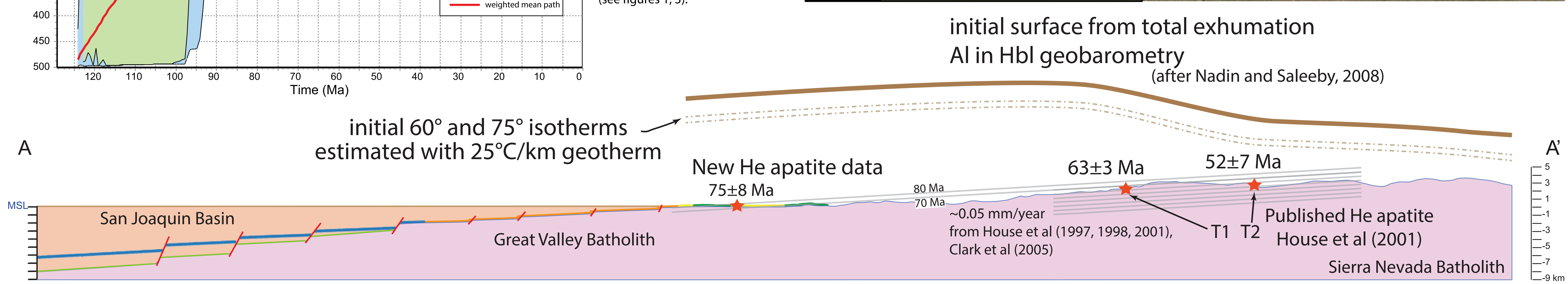


Figure 5. Cross Section A-A' modified after fig. 5A in Saleeby et al (in review). Apatite He data (red stars) are from this study, T1 (House et al., 1998) and T2 (House et al., 2001), errors are 1σ amongst data closest to cross section. Total exhumation from Al in hornblende data (Nadin and Saleeby, 2008) is drawn as thickness above smoothed modern topography assuming 1 kb ≈ 3.3 km. ~5 km additional exhumation of the GVB and western SNB relative to the eastern SNB is neither explained by low Cenozoic erosion rates nor the Cenozoic west-down tilt model, and requires >5 km of Cretaceous exhumation along the GVB/western SNB border. To illustrate the connection between the early western exhumation and the thermochronologic data, I utilize the isochrone conceptual model and draw approximate He apatite isochrone surfaces. Isochrones are assumed to be linear, tilting at 3.4° (McPhillips and Brandon, 2012). Mean apatite He ages from the pre-Eocene bedrock pediment is used to set the 75 Ma isochrone surface. 70 Ma and 80 Ma isochrone surfaces are drawn across the length of the transect. In the eastern SNB, post 80 Ma isochrones are spaced at the general rate of 0.05 mm/yr (Clark et al., 2005; House et al., 1998, 2001; House et al., 1997). Near the GVB/SNB boundary, pre 75 Ma isochrones are unknown. Filling this data gap would elucidate the rapid Cretaceous exhumation suggested by existing data (this study; Maheo, unpublished Zr He data). 60°C and 75°C paleoisotherms approximate the He PRZ relative to initial surface estimated from Al in hornblende geobarometry (Nadin and Saleeby, 2008)).

Acknowledgments

Special thanks to the Gordon and Betty Moore Foundation and the Caltech TO and the Farley Lab Group for supporting this research.

References:

Clark, M. K., Maheo, G., Saleeby, J., and Farley, K. A., 2005, The non-equilibrium landscape of the southern Sierra Nevada, California: GSA Today, v. 15, no. 9, p. 4-10.

House, M. A., Wernicke, B. P., and Farley, K. A., 1998, Dating topography of the Sierra Nevada, California, using apatite (U-Th)/He ages: Nature, v. 396, no. 6706, p. 66-69.

-, 2001, Paleo-geomorphology of the Sierra Nevada, California, from (U-Th)/He ages in apatite: American Journal of Science, v. 301, no. 2, p. 77-102.

House, M. A., Wernicke, B. P., Farley, K. A., and Dumitru, T. A., 1997, Cenozoic thermal evolution of the central Sierra Nevada, California, from (UTh)/He thermochronometry: Earth and Planetary Science Letters, v. 151, no. 3-4, p. 167-179.

McPhillips, D., and Brandon, M. T., 2010, Using tracer thermochronology to measure modern relief change in the Sierra Nevada, California: Earth and Planetary Science Letters, v. 296, no. 3-4, p. 373-383.

McPhillips, D., and Brandon, M. T., 2012, Topographic Evolution of the Sierra Nevada Measured Directly by Inversion of Low-Temperature Thermochronology: American Journal of Science, v. 312, no. 2, p. 90-116.

Nadin, E. S., and Saleeby, J. B., 2008, Disruption of regional primary structure of the Sierra Nevada batholith by the Kern Canyon fault system, California: Ophiolites, Arcs, and Batholiths: A Tribute to Cliff Hopson, GSA Special Paper, v. 438, p. 429-454.

Saleeby, J., Saleeby, Z., and Le Pourhiet, L. (in review), Epeirogenic transients related to mantle lithosphere removal in the southern Sierra Nevada region, California, Part II: Implications of rock uplift and basin subsid ence relations: Geosphere.

Saleeby, J. and Foster, Z., Topographic response to mantle lithosphere removal, southern Sierra Nevada Region, California: Geology, v. 37. p. 245-248.

Twidale, C. R., 1981, Origins and environments of pediments: Journal of the Geological Society of Australia, v. 28, no. 3-4, p. 423-434.

USGS, National Elevation Dataset 1/3 Arc Second, in The National Map Seamless Server, E. R. O. S., ed.: http://seamless.usgs.gov/products/3arc.php.