Geological Society of America
Structural Geology & Tectonics Division

2012
Outstanding Publication Award

Presented to Doug Yule and Kerry Sieh

Yule, D., & Sieh, K. (2003) *Complexities of the San Andreas fault near San Gorgonio Pass: Implications for large earthquakes.* Journal of Geophysical Research 108(B11), 2548. doi:10.1029/2001JB000451.

Citation byAndrew Meigs and Michele Cooke

Michele Cooke and I take great pleasure in recognizing Complexities of the San Andreas fault near San Gorgonio Pass: Implications for large earthquakes by J. Douglas Yule and Kerry Sieh as the 2012 Outstanding Publication Award of the Structural Geology and Tectonics Division of GSA.

Standing on the shoulders of such giants as Levi Noble, Clarence Allen, and others, Yule and Sieh integrated field structural data from the bedrock and deformed geomorphic markers, relocated catalog seismicity, and (U/Th)-He cooling ages to provide the first integrated crustal- scale model for the active fault systems at the southern end of the Big-bend of the San Andreas fault. The so-called 'San Gorgonio knot' is a place of profound significance because it separates the south-central and southern segments of the San Andreas fault. Whereas the south-central reach of the fault had earthquakes in 1812 and 1857, the southern reach of the fault has not ruptured since the late 1600's. Whether the knot represents a segment boundary in great earthquake ruptures on the San Andreas fault depends, in part, on the crustal- scale structural geometry of the fault through the knot. Yule and Sieh argue that structural complexities at the surface become organized into a single-strand fault at depth on the basis of regional seismicity. Their interpretation spawned a series of papers in the seismological community dealing with future rupture scenarios of the southern San Andreas fault, which represents a major source of concern because more than 300 years have passed since the last event on this ~240 year- recurrence interval section of the fault. Moreover, their work combined with many other's research prompted the Southern California Earthquake Center to identify the southern San Andreas Fault as a 'Special Fault Study Area' for the next 5 years.

The Yule and Sieh paper has implications for seismic hazard in southern California. Whether events on the southern San Andreas rupture through the knot depend the structural geometry at depth. The data and interpretations in the paper has been incorporated into the 2007 Working Group on California Earthquake Probabilities. The Yule and Sieh model informed, in part, the south to north through-going rupture scenario that formed the basis of the 'Great Southern California Shake Out', a region-wide earthquake simulation and disaster response exercises involving more than 6.9 million emergency responders and citizens in southern California.

Yule and Sieh's contribution represents a state-of-the-art paper in active tectonics because it integrates traditional structural methodologies, excellent field mapping, and seismology. Their unifying model reconciles a diverse suite of geological and geophysical data to provide a new perspective on the world's archetypal strike-slip fault. Their paper merits this award because of its implications for the structural evolution of strike-slip faults, for the tectonic evolution of western North America, for the active tectonics and kinematics of the Pacific-North America plate boundary, and, perhaps most significantly, for future rupture scenarios of the San Andreas fault and the associated seismic hazard for nearby Los Angeles and southern California.

On behalf of Michele and me and on behalf of the Structure and Tectonics Division, we applaud your creative integration to create a lasting contribution that has both scientific and societal implications. Congratulations.

Response by Doug Yule

It is a great surprise and honor to receive the 2012 Outstanding Publication Award, and I wish to thank the Division for selecting our paper. I wish first to thank Michele Cooke and Andrew Meigs for nominating this paper and for their kind and generous citation. I would also like to thank Adolph Yonkee and the Division's Selection Committee for the vital work that is involved in the selection process.

My introduction to the structural and tectonic problem at San Gorgonio Pass took place in 1989 on a Caltech field trip for new graduate students. Lee Silver and my coauthor led the trip, an inimitable pairing to say the least. Aside from the display of geologic jousting and posturing by the trip leaders, two things made an immediate and lasting impression. First, the strike-slip San Andreas Fault appears to disaggregate into a thrust-dominated system of faults in the pass. And second, the unusual structural complexity in the pass raises questions about how this structural knot might influence the rupture behavior of southern California's fastest moving fault. Understanding San Andreas Fault behavior in the pass therefore has important implications for assessing earthquake hazard and risk in southern California.

Seven years after that field trip, Kerry offered me a chance to work with him on the enigmatic San Gorgonio Pass as a Southern California Earthquake Center post-doctoral scholar. I jumped at the chance to work with Kerry who forty years ago helped launch the field of earthquake geology and active tectonics, showing that structural geologists and tectonicists could learn a great deal by studying dirt, by mapping surface traces of actively deforming faults and logging trenches across them. His visionary, painstaking research paved the way for more classically trained field geologists like me. While working on this project I was privileged to rub shoulders with a dynamic group of students, post-docs, and faculty that included some who are here at this meeing, including Anke Friederich, Andrew Meigs, Jim Spotila, Brian Wernicke, Mihai Ducea, and Jason Saleeby. This paper never would have materialized without the supportive environment that my friends and mentors at Caltech provided.

We would also like to thank USGS geologists Jonathan Matti and Doug Morton who shared their unpublished geologic mapping and acknowledge the years of hard work that they have dedicated

to unraveling the complex geologic history of the San Gorgonio Pass region. Our paper also greatly benefited from a thorough review by Jonathan Matti whose written review comments actually exceeded the length of the original manuscript! His comments and edits forced us to extensively revise the paper, which was published 2½ years after its initial submission. Your choice to honor this paper tonight therefore rewards this exhausting effort, and also illustrates that the peer-review process, which often imposes intensive and tedious rewriting, pushes the authors toward greater clarity and excellence.

Response by Kerry Sieh

Let me first echo Doug's thanks to Michele and Andrew for nominating our paper, and to the Division's selection committee for their decision. Let me also thank you, Doug, for doing most of the work to get it published. You are, my friend, one of the best field geologists that Caltech produced in the three decades that I was there. So when you emerged from the earlier-Cenozoic arena of your PhD and expressed an interest in working in a younger, active realm, I figured that the time had come to tackle what our Lamont colleagues had appropriately dubbed the "San Gorgonio knot." That structurally complex section of the San Andreas fault where it leaves metropolitan southern California and heads out toward Palm Springs and Mexico. Nowhere along its entire 1000-km length is it more complex and nowhere is its seismic potential as mysterious and consequential as there.

Now neither Doug nor I is a seismologist, so one might say that we were guilty of what G.K. Gilbert had long before called "scientific trespass." If so, we were latter-day trespassers, because by the time we started, earthquake science had metamorphosed into a much broader field than just seismology in the strict sense. Paleoseismology and neotectonics had already evolved successfully through their early decades. Practitioners of the former were digging up seismic times series that extended centuries and millennia into the past, while practitioners of the latter were defining the architecture and kinematic histories of Earth's active faults.

Clarence Allen had first recognized during his PhD work in the '50s that the wide dogleg in the San Andreas fault that transits San Gorgonio Pass is complex. By the mid-90s, paleoseismic work was hinting that sections of the fault to the NW and SE had different big-earthquake histories. So the big question had become this: Could great ruptures propagate right through those structural complexities. If so, the potential size of earthquakes would be much larger than if they could not. Moreover, if ruptures did propagate through the "knot," would they momentarily stall there: would the stepover be the reason for a short seismic stopover? Defining the structural architecture of the active strands of the fault system through the Pass had to be the first order of business in answering these two questions, because understanding kinematics precedes understanding dynamics.

So to understand the active tectonics, we combined mapping of faulted and folded crystalline and sedimentary rocks with geomorphological mapping of faulted and folded alluvial deposits and surfaces. What a marvelously complex architecture it turned out to be: A menagerie of big and small strike-slip, oblique-slip, normal and thrust faults, some active, others not; deformed old and young alluvial surfaces, landslides. To develop a 3D model of the fault zone extending through the brittle crust, we pulled in background seismicity, what was known about a few moderate historical earthquakes and what we knew about brittle-ductile transitions.

Our hope was that this would be a significant step toward reliable forecasts of the role that this section of the San Andreas will play in generating future great earthquakes. We are gratified that earthquake geologists, geodesists and geophysicists have already embarked upon additional research toward more reliable earthquake forecasts for this ominous historically dormant section of the fault.

We thank the Structural Geology division for the recognition that this award bestows both on our work and on the importance of this largely structural problem.