Geological Society of America

Structural Geology & Tectonics Division

2006
Best Paper Award

Presented to Tim Dixon, Meghan Miller, Fred Farina, Hong Wang, and Daniel Johnson

Dixon, T.H, Miller, M., Farina, F., Wang, H. & Johnson, D. (2000) *Present-day motion of the Sierra Nevada block and some tectonic implications for the Basin and Range province, North America Cordillera*. Tectonics 19, 1-24

Citation by John Weber

I am pleased to announce, albeit belatedly and with our apologies, Tim Dixon and coauthors Meghan Miller, Fred Farina, Hong Wang, and Daniel Johnson as the 2006 recipients for the Best Paper Award for their 2000 *Tectonics* paper on the motion of the Sierra Nevada block (microplate) and tectonic implications for the Basin and Range. To my knowledge this is the first Best Paper awarded by the Structural Geology and Tectonics Division that uses high- precision (geodetic) GPS as its primary data source. The study reflects an exciting new direction in our field: not simply using high-precision (geodetic) GPS to observe structures form right before our eyes, but also gauging and comparing this "instant snapshot" of deformation with longer time-scale records provided by the geologic and historic archives. This is not "black box" science. The 2000 paper by Tim and his colleagues clearly lays out how to do this sort of work thoughtfully and carefully.

Although the authors use primarily GPS data, this paper is not simply a study of modern-day kinematics; it goes on to a deeper level and addresses some geologic, historic, and dynamic issues as well.

Tim and his coauthors derive the first Euler pole (angular velocity vector) describing the motion of the Sierra Nevada block relative to North America that uses *only* data from sites in the rigid interior of the microplate. The result is a robust estimate showing that the microplate translates nearly parallel to Pacific-North America plate motion about a *distant* pole of rotation. The paper exploits this kinematic boundary condition, using it to go on to address a number of smaller-scale tectonic problems.

The study takes a sophisticated look at elastic, viscoelastic, and earthquake cycle effects, on geodetic slip-rate determination. By presenting a clear and logical exposition of these effects, the paper explains why there is such a great spread in slip-rate estimates, and resolves the long- standing discrepancy between geodetically and geologically derived slip-rates across some of the most important active faults in this region (e.g., Owens Valley Fault). This issue is more fully explored in a later paper that Tim and two student co-authors published in Geology in 2003. This follow-up study went on to use these same geodetic and historic earthquake data and viscoelastic models to *predict* earthquake recurrence intervals, turning the familiar paleoseismology technique upside down onto its head.

The authors next develops the interpretation that 11±1 mm/yr, a full 1/5 of the 50+ mm/yr of overall plate motion, is taken up in the eastern California shear zone (ECSZ), primarily across two faults, the Owens Valley/White Mountain and Fish Lake Faults. The authors show that the

ECSZ is the locus of the most significant velocity gradient east of the Sierra Nevada block, and that this high strain zone coincides with a very strong surface heat flow gradient. The paper suggests that this coincidence is no accident; the cold Sierra Nevada-Great Basin/warm Basin and Range transition provides an easy conduit for strain localization. This important dynamic coincidence is confirmed and explored in more detail in a subsequent (2001) finite element modeling paper by Tim and co-authors Rocco Malservesi and Kevin Furlong.

In closing, Tim and his colleagues' 2000 *Tectonics* and derivative follow-up papers present clear, thoughtful, and logical examples of how to use high-precision (geodetic) GPS to first define a set of far-field kinematic boundary conditions, then how to combine the GPS data in a logical way with historic earthquake data and geologic data to explore a number of significant and interesting regional tectonics problems. Once the kinematics are clear, the possibility for recognizing dynamic cause and effect relations opens up. When the work is carefully done, as in this paper, it's a pretty good bet that the answers you get out really mean something in the end. Congratulations to Tim and colleagues for a study well done and well presented. We look forward to learning more from you in the future.

Response by Tim Dixon

On behalf of my co-authors, Meghan Miller, Fred Farina, Hongzhi Wang, and Dan Johnson, I'd like to thank GSA and the Structural Geology and Tectonics Division for this award. Dan passed away two years ago in a tragic car accident while engaged in field work similar to the research honored here tonight. He would be very pleased with this award, and I hope my remarks capture some of the feelings I know he would have expressed.

I'd also like to thank my wife Jackie, who helped with some of the early field measurements associated with this research, and has always been supportive despite having a very productive career of her own in earth sciences.

I am both honored and humbled by this award. I am honored because the committee who selected our paper for this distinction has placed us in a very elite group, namely the previous recipients of this award.

I am humbled because the award has reminded me that the work described in our paper (high precision GPS measurements bearing on the tectonics of the western Basin and Range and Eastern California Shear Zone) would not have been possible without the contributions of a large number of dedicated scientists and engineers. These people make up the discipline we call space geodesy. It is usually not possible to recognize their contributions in a formal way, but I would like to try to remedy that now.

These days most geologists take it pretty much for granted that an inexpensive GPS receiver can tell you where you are within a few meters. But to support the type of measurements necessary for tectonic applications, typically requiring position estimates precise to a few millimeters, we need a large group of dedicated geodesists who maintain a sophisticated global system of

observations and analysis. Moreover, the system we use today reflects three decades or more of research and development spanning a whole array of scientific and engineering disciplines.

Beginning about twenty five years ago, shortly after a talented group of engineers developed and launched the satellite navigation system called GPS for the US Department of Defense, several clever people figured out that the same signals used for navigation could also be exploited for high precision geodesy. This achievement built on developments in Very Long Baseline Interferometry (VLBI) and Satellite Laser Ranging (SLR) supported by NASA, NOAA, the Navy, and several European institutions. While these systems were too large and expensive for most tectonic applications, many of the lessons learned applied to GPS, for example how to determine high precision ephemerides (a description of satellite position as a function of time) in the case of SLR, and how to calculate and correct for the effects of signal propagation through the atmosphere in the case of VLBI. On-going efforts since then in areas as diverse as orbital mechanics, atmospheric physics, electronics design, signal processing, and modeling of geophysical processes have succeeded in improving GPS precision by about three orders of magnitude beyond its original design level.