Nomination of Dr. Kelin Wang for the 2015 J.Tuzo Wilson Medal

We are very pleased to nominate Dr. Kelin Wang for the J. Tuzo Wilson Medal for 2015. Dr. Wang is deserving of this award for his fundamental contributions to observation, theory and modeling of earthquake and geodynamic processes at subduction plate boundaries and for exceptional contributions in geophysical modelling.

Dr. Wang has been a pioneer and world leader in scientific research of geodynamic and earthquake aspects of subduction zones. Much of his work has focused on geophysical modelling which he has used to derive profound insights into key subduction zone processes, including megathrust earthquake cycles, crust/mantle rheology, mantle dynamics, and episodic tremor and slip events. The impact of his research has been significant and far-ranging. His thermal models revolutionized our understanding of petrologic, rheological, hydrological, and volcanic processes in subduction zones and how these processes control earthquakes along the plate interface and within the subducting lithosphere. His models of forearc stress and strain as controlled by gravity and subduction earthquake cycles reconciled seemingly paradoxical observations and established the intrinsic weakness of subduction faults. He is one of the discoverers of episodic tremor and slip and was responsible for proposing the model of slow slip event along the subduction interface downdip of the seismogenic zone. His dynamic Coulomb wedge theory provided new concepts to link long-term deformation of accretionary prisms to subduction earthquakes. His viscoelastic models of subduction earthquake cycles represent the state of the art in this field and form the primary conceptual framework for both theoretical and experimental developments in this research. More recently, he has championed a new theory of how the roughness of subducting seafloor controls the occurrence of great earthquakes.

It is not only his expertise and breadth of knowledge, but also his creativity, productivity, enthusiasm for sharing research, leadership in scientific organizations, excellence in mentoring and teaching, and his uncanny ability to explain complex processes in simple terms that make Dr. Wang a much sought-after research collaborator, guest professor, member of editorial boards and research panels, and invited speaker at numerous international conferences. Beyond his scientific acumen and prodigious scientific productivity, Kelin is an incredibly nice guy, very accessible and happy to engage in a wide range of projects, problems, and conversations, with almost anyone on all topics. The world is a better place because of his contributions, both to the discipline and to society. There is no question that Dr. Kelin Wang is a most worthy recipient of the CGU's highest award, the J.Tuzo Wilson Medal.

Respectfully submitted,

Dr. H. Dragert Dr. J. Henton Dr. T. James

Brief Biography for Dr. Kelin Wang

Kelin Wang obtained his B.Sc. in geology at Peking University in 1982, and Ph.D. in geophysics at the University of Western Ontario in 1989. After teaching at the University of Western Ontario as a lecturer for a year, he joined the Geological Survey of Canada, first as a Canadian Government Laboratory Visiting Fellow, then as a Research Scientist. He applies mathematical and numerical methods to geological and geodynamic problems and is known for his ability to develop elegantly simple concepts and models to explain complex and multidisciplinary observations. Early in his career as a geophysicist, he devised advanced inverse methods for coupled geothermal and hydrogeological systems and pioneered the field of using subsurface temperatures to infer past climate change. Since 1993, his research focus has been primarily subduction zone geodynamics and related earthquake processes, although he has also made significant contributions to other research fields such as the hydrogeology of the oceanic lithosphere and earthquake hazard and risk assessment. His thermal models revolutionized our understanding of petrologic, rheological, hydrological, and volcanic processes in subduction zones and how these processes control earthquakes along the plate interface and within the subducting lithosphere. His models of forearc stress and strain as controlled by gravity and subduction earthquake cycles reconciled seemingly paradoxical observations and established the weakness of subduction faults. He is one of the discoverers of episodic tremor and slip and was responsible for proposing the model of slow slip event along the subduction interface downdip of the seismogenic zone. His dynamic Coulomb wedge theory provided new concepts to link long-term deformation of accretionary prisms to subduction earthquakes. His viscoelastic models of subduction earthquake cycles represent the state of the art in this field and form the primary conceptual framework for both theoretical and experimental developments in this research. More recently, he has championed a new theory of how the roughness of subducting seafloor controls the occurrence of great earthquakes. He is an Adjunct Professor at the University of Victoria and an Honorary or Guest Professor for several other scientific institutions. He is Editor-in-Chief for scientific journal Tectonophysics and was or still is on the Editorial Boards of a number of other journals such as Journal of Geophysical Research (Associate Editor), Geology, Journal of Geodynamics, Science in China (Earth Science), and Earthquake Science. He was formerly the Secretary of the Canadian Geophysical Union and Chair of the International Professionals for the Advancement of Chinese Earth Sciences.

Dr. Kelin Wang, acceptance speech for 2015 J. Tuzo Wilson Medal

Mme. President, Esteemed Colleagues, Ladies and Gentlemen,

It is a great honour to be awarded the J. Tuzo Wilson Medal by the Canadian Geophysical Union. It is rather special to be recognized in this fashion by the first learned society that I ever joined, the society for which I proudly served as Secretary for four years. I thank Herb Dragert, Joe Henton, and Tom James for leading this nomination and the colleagues who wrote supporting letters for this nomination. Thank you, Roy, for delivering those generous words.

I envy many of the previous Wilson medalists who in their acceptance speeches were able to recall their personal interactions with Tuzo Wilson. I never had the opportunity to meet Tuzo Wilson, let alone to work with him, but I feel equally privileged to be able to acknowledge the influence, encouragement, and help I obtained throughout my career from many other wonderful colleagues.

I had my undergraduate education in Geology at Peking University. My B.Sc. thesis project was to study an active fault near Beijing by mapping river terraces and Quaternary deposits. The geological training was somewhat non-traditional: We had a course program emphasizing mathematics and mechanics that was newly designed by Professor Ren Wang. Ren Wang quit his faculty position at Illinois Tech in the U.S. and returned to China in 1955. During the Cultural Revolution of 1966–1976, he was kicked out of the Department of Mathematics and Mechanics for ideological reasons but was adopted by the Department of Geology. He then began to apply mechanical theories and mathematical methods to geological problems and rose to be, in the words of the great Kei Aki, “the founding father of geodynamics in China”. As the first group of students in this new program, we were told that we were expected to grow into “bridges”, bridges that would connect geological observations and mathematical models. This bridge concept has guided me through my career and defines what I am today. I thank the many teachers at Peking University, especially Ren Wang and Yongen Cai, for setting me on track.

After obtaining a B.Sc. in geology, I obtained a Chinese scholarship to pursue graduate study in Canada. With the dream to become a bridge, I applied for geophysics programs in three Canadian universities, with a success rate of 33%. One university did not think my geological background was adequate for geophysics and rejected my application. Another responded after several months, pointing out that my application was incomplete because I had missed signing one of the forms. Fortunately my top choice, University of Western Ontario (now Western University) replied positively and immediately. Therefore, in January 1984, I became a graduate student under the supervision of Alan Beck. Alan is a world leader in the study of terrestrial heat flow and was awarded the Wilson Medal in 1993. I measured thermal conductivities in Alan’s lab and logged boreholes across Canada. Not very impressed with my potential as an

experimentalist, Alan encouraged me to pursue modeling. This echoed with not only my desire to become a bridge but also my naïve view of the time that complex mathematics represented scientific advancement. With the generous help of Po-Yu Shen, then working with Alan, I ventured into geophysical inversion, coupled heat flow and groundwater flow, and finite element modeling. Although no geodynamics, the training I obtained during my Western time would later prove to be very valuable.

In 1990, Trevor Lewis of the Pacific Geoscience Centre (PGC), Geological Survey of Canada, hired me as a post-doctoral fellow under the Canadian Government Laboratory Visiting Fellow program. I do not know how Trevor managed to convince the management to hire me, given that my PhD research had nothing to do with the type of geodynamic research being pursued at PGC, let alone the priorities of the majority Party in Ottawa. Without any assigned task or expectation from anyone in the GSC, I began to invert borehole temperature measurements to infer past climate change and made some major progress. In the meantime, others at PGC began to try to talk me into something more relevant to their typical research. Three people got me into subduction zone research, a field that was completely new to me. Roy Hyndman, who would be a Wilson medalist in 2001, thought my thermal modeling experience could be used to study the temperature condition of subduction megathrust earthquakes. Herb Dragert, who would be a Wilson medalist in 2007, thought my knowledge of finite element modeling could be used to study interseismic deformation. Garry Rogers, the living dictionary of Canadian earthquakes, enticed me to work with him to explain a double seismic zone in the subducting slab in southernmost Cascadia. I was tremendously fascinated by their thermal, geodetic, and seismological observations and their scientific ideas. Once I was exposed to the wonders of subduction zone geodynamics, there was no turning back. I also found my way to become a bridge between observations and theories, the type of bridge that I had always wanted to be.

We live in an exciting time of subduction zone research. For the four decades from the mid-1960's through December 2004, the world's subduction zones were rather quiet in terms of producing earthquakes and tsunamis, but major breakthroughs in research still happened. In 1987, just three years before I joined PGC, Brian Atwater of USGS published a seminal paper on coastal geological evidence for past great Cascadia earthquakes. It was a perfect time to embark on subduction zone research with Cascadia as a primary focus. I was fortunate to witness or participate in a number of subsequent breakthrough discoveries. By the mid-90's, it became clear that the Cascadia megathrust is locked to accumulate energy for a future great earthquake and that the locked zone is mostly offshore. Roy Hyndman proposed temperature constraints on the rupture zone of megathrust earthquakes. In 1996, Kenji Satake and others reported Japanese historical records of a trans-Pacific tsunami generated by a great Cascadia earthquake in 1700. In the meantime, Steve Kirby and Simon Peacock led the way to link earthquakes within the subducting slab to metamorphic dehydration processes. The beginning

of the 21st century saw the discovery of Episodic Tremor and Slip (ETS), championed by Herb Dragert, Garry Rogers, and Kazushige Obara, and the discovery of opposing motion of coastal and inland GPS stations some 40 years after the giant Chile and Alaska earthquakes in the 1960's, led by Jurgen Klotz, Gia Khazaradze, Jim Savage, and others; these discoveries completely changed our view of fault friction and how mantle viscoelasticity controls earthquake cycles. Since December 2004, great earthquakes have occurred much more frequently, including a few devastating subduction zone events such as the 2004 Sumatra and 2011 Japan Trench earthquakes and their tsunamis. Life and property losses caused by these events saddened us, but the massive data from them recorded by modern networks also greatly accelerated scientific advancement. Every event brought scientific surprises, and our understanding of how subduction zones and their earthquake cycles work have been updated on a yearly basis. It is truly fulfilling to be able to stay at the forefront of these developments, serving as a bridge between observations and geodynamic theories. In addition to the names mentioned above, I should acknowledge a number of other international colleagues who influenced or helped me in my pursuit of subduction zone geodynamics, such as Kiyoshi Suyehiro, Jay Melosh, Ray Wells, Onno Oncken, Julia Morgan, George Spence, Shuichi Kodaira, Makoto Yamano, Susan Bilek, Ryota Hino, Tim Dixon, Wayne Thatcher, Dapeng Zhao, Honn Kao, Tom James, John Cassidy, Yajing Liu, David Scholl, Roland von Huene and many other names that cannot all be listed here because of space and time limits.

Being able to claim to be a bridge between observations and theories is not without going through major challenges. One challenge was that I was somewhat handicapped in physics. In my four undergraduate years at Peking University, I took some 40 courses and scored straight A's expect two for which I scored B. One of the two was "History of the Chinese Communist Party". The other, shame on me, was General Physics. Even with a PhD degree a few years later, I was still a lot more comfortable with math and geology than with physics. My brain was re-wired after I began to work with Earl Davis at PGC. Working with Earl, and later also with Garth van der Kamp (the Wilson medalist in 2009), on the problems of hydrothermal circulation, poroelasticity, and tidal energy dissipation, I began to appreciate that doing geophysics is about developing intuition on the various conservation laws. At first I was often amazed that Earl and Garth were able to predict main model results before I even began to write a code to solve the problem. From them, I learned to think physics without reciting equations and to predict results using scale lengths, time constants, and back-of-the-envelope calculations. Only after this transformation, did I begin to feel confident in being a bridge. There was another major challenge: as I was devouring and detangling various geophysical and geological observations, I was out of steam on the technical side of modeling. We needed to deal with thermal conduction and convection, viscoelasticity, plasticity, friction, poroelasticity, and viscous mantle flow, often in nonlinear and 3D forms and with parallel computing. I had neither the skill nor the energy to do it all. As the bridge was on the verge of collapsing in 1995, there came the

extraordinarily gifted John (Jiangheng) He. One of my greatest contributions to Earth science is to convince John He to work on geodynamics and to stay at PGC. John is not only responsible for writing almost all of our finite element codes and setting up our high-performance computing facilities but also the “go to” person for all the mathematical and most computer problems that I have encountered. John He is certainly one of the people I wish I could share the Wilson Medal with.

I am extremely privileged to have worked with a number of remarkably talented students and post-docs, of the calibre of Claire Currie, Ikuko Wada, Yan Hu, Tianhaozhe Sun, and Xiang Gao. Their passion and dedication for science and their hardworking have always been my inspiration. Whatever I have managed to achieve, credits go to them!

I thank my wife Zhen Lin and daughters Lynn and May for giving me a loving family, for understanding and tolerating my workaholic lifestyle, and for giving me unconditional support at all times. I also thank my two brothers living in Beijing for looking after my mother to allow me to focus on my work in Canada for all these years. Thank you all!