

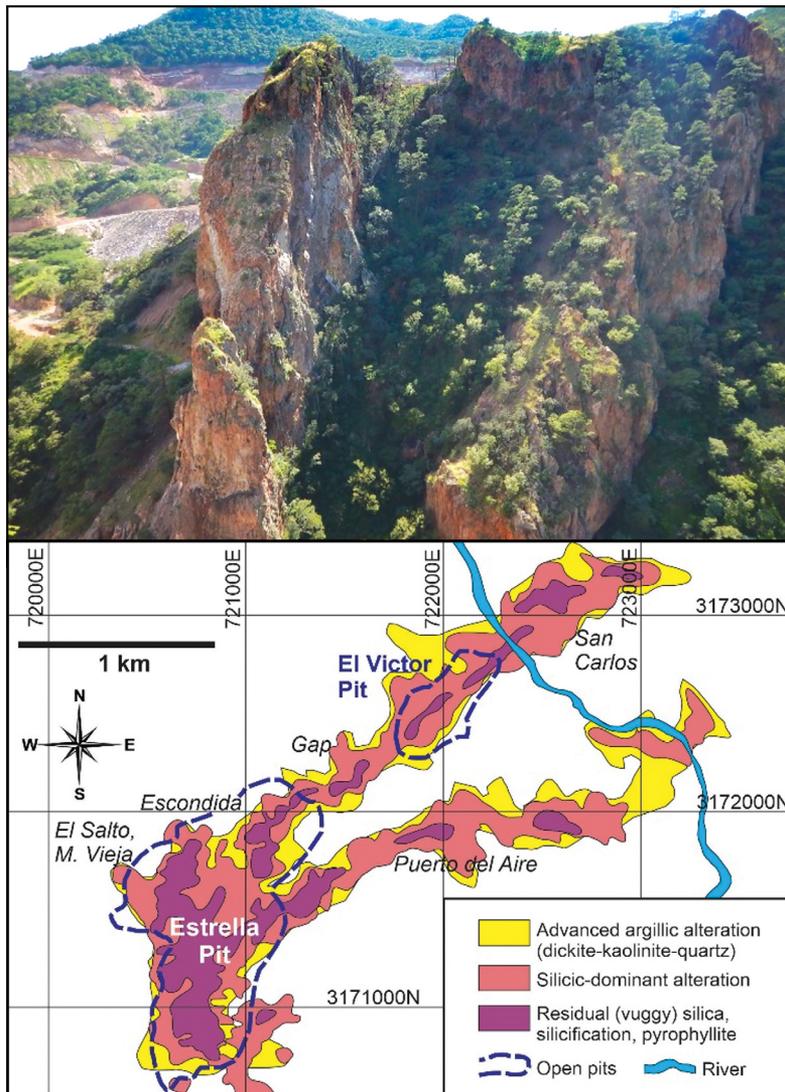


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# REVIEWS IN ECONOMIC GEOLOGY

Volume 21

## APPLIED STRUCTURAL GEOLOGY OF ORE-FORMING HYDROTHERMAL SYSTEMS



Editors

Julie V. Rowland and David A. Rhys

SOCIETY OF ECONOMIC GEOLOGISTS, INC.



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## APPLIED STRUCTURAL GEOLOGY OF ORE-FORMING HYDROTHERMAL SYSTEMS

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SOCIETY OF ECONOMIC GEOLOGISTS, INC.

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*Reviews in Economic Geology* is a series publication of the Society of Economic Geologists, originally designed to accompany the Society's Short Course series. Each volume provides comprehensive updates on various applied and academic topics for practicing economic geologists and geochemists in exploration, development, research, and teaching.

*On the cover:* Front: Photo and plan map from the Mulatos district, Mexico, showing alteration zonation. The linear fault-controlled alteration zones host gold mineralization in areas of resistant weathering with residual silica and silicification. Structural controls on epithermal gold-silver deposits are described in the paper by Rhys et al. in this volume. Back: Low-sulfidation epithermal quartz-adularia-calcite Au-Ag vein, Colorado Grande vein system, Midas Deposit, Nevada. The image illustrates the textural and mineralogical evolution of the fault-hosted vein system during seismically induced dilational events that contributed to the formation of the deposit. Photo by D. Rhys, August 2002.

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## DEDICATION

Richard H. Sibson



*Emeritus Professor of Geology, University of Otago*  
*Fellow of the Royal Society*  
*Fellow of the Royal Society of New Zealand*  
*Fellow of the Society of Economic Geologists*  
*Society of Economic Geologists R.A.F. Penrose Gold Medalist*

This volume is dedicated to Richard H. Sibson, a teacher, storyteller, and intellect who has inspired many through his work at the nexus of structural geology and geophysics. Rick has illuminated our understanding of crustal-scale fluid redistribution, active tectonics, and hydrothermal mineralization.





## Preface

The concept for this Reviews volume was initiated in 2013 when Julie Rowland invited Dave Rhys to deliver a short course on gold deposits—their structure and setting—to students, academics, and industry representatives at the University of Auckland, New Zealand. Motivations were undeniably selfish—Julie wanting to learn as much as she could from Dave’s experience in applying structural geology to gold deposits, and Dave keen to apply Julie’s knowledge of the structure of the Taupo volcanic zone to a better understanding of epithermal environments. We began talking and realized that, although some excellent publications exist (e.g., the wonderful Reviews in Economic Geology Vol. 14, *Structural Controls on Ore Genesis*), there was a gap at the applied structural geology end of the spectrum. Where should an exploration geologist or young researcher look for guidance on applied structural geology?

We ambitiously decided to pull together a Reviews volume to provide guidance to working geologists and researchers tasked with applying concepts of structural geology to mineral exploration. Given our respective backgrounds and interests, we honed the scope down to ore-forming hydrothermal systems and set about inviting top practitioners and researchers from around the globe to contribute their wisdom.

The result is a volume that spans theory and practice across mineral deposit types at a variety of scales. The volume starts with two scene-setting chapters. First, Tom Blenkinsop, Nick Oliver, Paul Dirks, Michael Nugus, Gerard Tripp, and Ioan Sanislav demonstrate how principles of structural geology can be applied to understanding hydrothermal gold deposits using predominantly lode gold case studies. They describe a classic workflow with reference to examples and useful resources. Stephen Cox then delves into the processes that drive metal-carrying fluids through the accessible crust and optimize ore formation. This richly illustrated chapter considers feedback between fluid flow and deformation and sets the theoretical foundation for understanding from a structural perspective where and why ore formation occurs within hydrothermal systems. Cox’s chapter provides the heft to underpin predictive structural frameworks for targeting.

Chapters 3 through 5 then provide first-class examples of applied structural geology specific to different deposit types. These three chapters were selected to illustrate contrasting structural contexts with varying styles of behavior, influence of host-rock and deposit rheology, and proximity to a magmatic source. In Chapter 3, David Rhys, Peter Lewis, and Julie Rowland review structural controls on ore localization in epithermal gold-silver deposits. This chapter takes a minerals systems approach, working from province to deposit scale and complementing many of the concepts introduced by Cox in the previous chapter. The lead author’s breadth of experience is on show here, with superb illustrations and plentiful photographs drawn from unpublished industry studies that supplied unprecedented access to orebodies. Bruno Lafrance, Harold Gibson, and Margaret Stewart consider ancient volcanogenic massive sulfide (VMS) deposits. This chapter highlights the important influence of primary features of deposits on the subsequent development

of tectonic structures. The rheological influence of sulfides is well illustrated from thin-section to deposit scale. While this chapter focuses on a specific deposit type, the influence of weak materials on deformational and hydrothermal history is relevant elsewhere (e.g., timing of gold mineralization in lode gold deposits). In Chapter 5, Richard Tosdal and John Dilles apply a structural geologist’s lens to porphyry copper deposits, where the ore-forming environment is influenced by interplay between magmatism, tectonism, and hydrothermal flow. This chapter illustrates the features and fabrics of porphyry copper deposits using conceptual cartoons, selected photographs, and case studies acquired from the authors’ geographically expansive experience.

In Chapter 6, Tom Blenkinsop, Julie Rowland, and Tim Baker draw on the preceding chapters to consider the mechanics of hydrothermal gold mineralization. This short chapter consolidates earlier observations and theoretical considerations into a mechanical facies model for different deposit types—one that emphasizes considerable overlap in fields.

The volume concludes with three unapologetically practical chapters that illustrate good practice (and common pitfalls) in core shed or largely desktop aspects of exploration that require a high quality of applied structural geology. In Chapter 7, Julia Kramer Bernhard, Wayne Barnett, Ron Uken, and Russell Myers provide a thorough review of the structural analysis of drill core for mineral exploration. They propose standardized workflows for data collection, review technological advances and quality control processes, and provide an overview of structures that may be observed in drill core. This chapter illustrates a workflow toward domain-based 3-D interpretation.

Paul Stenhouse, James Haythornthwaite, and Oliver Jones follow with a chapter that applies structural geology in the context of 3-D geologic modeling. They present a three-step workflow that includes establishing a geologic framework through field work and 3-D visualization, modeling the project-scale geology, and finally, identifying, modeling, and understanding controls on ore shoots.

Lastly, James Siddorn, Peter Williams, David Isles, and Leigh Rankin take us back out to the district scale with Chapter 9, which reviews integrated geologic-geophysical interpretation of structural frameworks to target orogenic mineralizing systems.

As everyone who has contributed to a Reviews volume knows, it’s a long, hard process. We would like to thank all the authors and reviewers, especially our industry and consulting colleagues who took time away from the day job to make this volume happen. Thanks also to all the sponsors for their generous support, and the staff at SEG headquarters for their diligent conversion of raw manuscript to polished product. We hope that we have at least partially achieved our ambition. If this volume gets well-thumbed by a generation of exploration geologists, especially those for whom structural geology is not their forté, we will be delighted.

Julie Rowland and David Rhys





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## Author Biographies

**Tim Baker** has been chief geoscientist for Eldorado Gold Corporation since 2012. Tim is a graduate of the University of Cardiff, Wales, and holds a doctorate in geology from James Cook University in Australia. He has over 20 years of experience working in industry, academia, and government, including research and academic positions at the Mineral Deposit Research Unit, University of British Columbia, and James Cook University, and positions as director of the Geological Survey of South Australia and exploration manager of Sovereign Metals. In 2002 Tim received the Society of Economic Geologist's Lindgren Award.

**Wayne Barnett** is the principal consultant, structural geology, with SRK Consulting in Vancouver, Canada. Wayne has over 20 years of experience in mapping, interpreting, and 3-D modeling of structural geology and has performed the role of consulting structural geology specialist in mining and exploration in Africa, North America, South America, Asia, and Australasia. Wayne has also been employed over a period of eight years as a mining operations-based geotechnical engineer and is keenly focused on developing improved systems for integrating good applied structural geology with geotechnical design. He has provided formal applied structural geology training to over 1,000 geologists and engineers internationally, including specialized 3-D structural modeling training, and is currently driving the development of new innovative data collection technologies.

**Tom Blenkinsop** is a professor at the School of Earth and Ocean Sciences, Cardiff University. He applies structural geology to the study of natural resources. His research focuses on faulting and fluid flow and structural controls on mineralization at all scales. He works extensively with the exploration and mining industry, mainly on copper, gold, and iron oxide copper-gold deposits. Tom graduated from Oxford University and completed an M.Sc. degree at Imperial College before undertaking his doctorate at Keele University and postdoctoral research at the University of California, Santa Barbara. He was a professor at the University of Zimbabwe and then at James Cook University in Australia, where he was director of the Economic Geology Research Unit. He has published over 150 papers, one textbook, and an online course in structural geology for exploration and mining. He is an editor of *Ore Geology Reviews*.

**Stephen Cox** is a professor of structural geology in the Research School of Earth Sciences at The Australian National University, Canberra, Australia. His research interests are primarily in the coupling between deformation processes and fluid flow in crustal regimes, with applications to ore genesis and crustal mechanics. His research is pursued via field-based studies, microstructural, microchemical, and stable isotope analyses, high-pressure-high-temperature rock deformation experiments, and numerical modeling. He holds a B.Sc. (Hons) degree from the University of Tasmania, Hobart, Australia, and a Ph.D. degree from Monash University, Melbourne, Australia. Stephen was the Society of Economic Geologists Distinguished Lecturer in 2007.

**John Dilles** was born in California and earned degrees in geology from Caltech (B.S., M.S.) and Stanford University (Ph.D., 1984). He has worked as an exploration geologist for Hunt, Ware and Proffett and operated small gold mines with his brother, Peter. He joined the faculty of Oregon State University in 1986, where he is currently professor of geology in the College of Earth, Ocean and Atmospheric Sciences. He advises graduate students and teaches courses in petrology-geochemistry, field geology, and minerals deposits. His research focuses on the geology of cordilleran porphyry copper deposits, magmatic processes that generate metal and sulfur-bearing hydrothermal fluids, field-based structural geology, and isotopic tracers and geochronology. He is a Fellow and Silver Medalist of the Society of Economic Geologists.

**Paul Dirks** is professor of geology and codirector of the Economic Geology Research Centre at James Cook University, Townsville, Australia. He obtained an M.Sc. degree (geology) from Utrecht University (1987) and a Ph.D. degree (geology) from the University of Melbourne (1990). Paul is an elected Fellow of the Society of Economic Geologists. He is a structural geologist with an interest in the tectonic history of cratonic terrains, investigating their evolution and associated mineralization patterns. Paul's research is field oriented with a focus on detailed mapping and field-based geologic analyses. Paul has worked extensively as a professional consultant to the mining industry, is a past director of SRK-Zimbabwe and past associate of SRK-South Africa, and has served as an expert member on mining and public projects. His consulting work has focused on structural mapping, geotechnical work in open pits, and gold and base metal exploration.

**Harold Gibson** is professor of volcanology and ore deposits at the Harquail School of Earth Sciences, Laurentian University. He was director of the Mineral Exploration Research Centre from 2002 to 2017 and is the founding director of Metal Earth. Harold's research is field based and focuses on submarine volcanism and volcanogenic massive sulfide ore systems, including the volcanology of epithermal precious metal deposits. He has extensive expertise on volcanogenic massive sulfide deposits globally, including those of the modern seafloor, and has consulted for Canadian and International mining companies and governments. Harold obtained his B.Sc. degree from Queen's University and his M.Sc. and Ph.D. degrees from Carleton University. He is a recipient of the William Harvey Gross Award and the Duncan R. Derry Medal from the Mineral Deposits Division of the Geological Association of Canada, the Barlow Memorial Medal and the Julian Boldy Memorial Award from the Canadian Institute of Mining and Metallurgy, and the 2018 Research Excellence Award from Laurentian University.

**James Haythornthwaite** is a senior consultant in resource geology at SRK Consulting (UK) Ltd. He completed a B.Sc. degree in geology at Durham University in 2009 and an M.Sc. degree in mining geology at Camborne School of Mines, University of Exeter, in 2011. James has worked as a resource geologist at SRK since 2011, specializing in 3-D geologic

## Biographies (continued)

modeling, resource estimation, and the interpretation of structurally complex mineral deposits. During this time, he has worked on a large range of deposit styles and commodities, including iron ore, base metals, precious metals, and colored gemstones, across Europe, Africa, South America, and Asia.

**Dave Isles** holds a B.Sc. (Hons) degree in geophysics from Melbourne University (1975) and a Ph.D. degree in economic geology from Adelaide University (1983). He has worked primarily in mineral exploration since 1976 and has been involved in projects for gold, base metals, diamonds, and iron ore in Australia and in Africa, Canada, India, the Middle East, and Southeast Asia. After completing a research project on the Broken Hill region, New South Wales, in 1979, Dave spent seven years with BHP Minerals as a project geophysicist and then joined airborne contractor World Geoscience Corporation, specializing in the interpretation of aeromagnetic data. In 1993, he formed an independent consultancy and undertook directorships of junior mining and exploration companies. He has maintained substantial involvement with research and development and training activities, delivering industry workshops on aeromagnetic data and coauthoring a book on this topic. He currently is an exploration consultant with Southern Geoscience and is a member of the Australian Society of Exploration Geophysicists and the Australian Institute of Geoscientists.

**Oliver Jones** is a director at Impala Geomodelling, a 3-D modeling and mineral exploration consultancy based in the United Kingdom. He completed his undergraduate studies at Cardiff University in 2008 and then spent the following four years with a Canadian junior exploration company, developing gold projects in Tanzania and Namibia. During this time, he also completed an M.Sc. degree in mining geology at the Camborne School of Mines. Oliver subsequently worked for four years with SRK Consulting (UK) Ltd. as a resource geology consultant, focusing on 3-D modeling and exploration in a variety of commodities and deposit types. Oliver established Impala Geomodelling in early 2017 and currently works with a number of major and mid-tier producers across the globe, building complex 3-D models for resource estimation and exploration.

**Julia Kramer Bernhard**, Ph.D., is the lead of structural geology at Anglo American and provides structural geologic leadership and support to Anglo American's operations and exploration projects globally. She has over 25 years of experience in the mineral exploration industry, government, and academia and specializes in the structural control of mineralization and the delineation of structures for geotechnical rock mass characterization. Drawing from extensive field experience, Julia visualizes geometries, model confidence, and alternative scenarios in integrated and validated geologic and uncertainty models. She champions the development and implementation of structural geologic technical standards for data collection and modeling at all stages of the mining cycle. Presently, she takes an interest in automating data collection, correlation, analysis, and modeling

to maximize insight from the data collected and accelerate the drilling-to-model workflow.

**Bruno Lafrance** is a professor of structural geology at the Harquail School of Earth Sciences, Laurentian University. His research focuses on the primary structural controls on the formation of ore deposits and their subsequent modification during orogenic events. Although most of his research has been on gold and volcanogenic massive sulfide deposits, Dr. Lafrance also researched the structural controls on the formation and modification of Ni-Cu-platinum group element deposits in Sudbury, Ontario. Bruno holds a Ph.D. degree in geology from the University of New Brunswick and a B.Sc. degree in geology from the Université de Montréal. In 1999, he joined the Department of Earth Sciences (now Harquail School of Earth Sciences) at Laurentian University, where he teaches courses in structural geology and field geology and does research in structural geology applied to ore deposits. Bruno was a member of the team who proposed the successful Metal Earth project, the largest mineral exploration research initiative in Canadian history, and is now serving as associate director of Metal Earth.

**Peter Lewis** completed his B.S. degree at Stanford University in 1984 and his Ph.D. degree at the University of British Columbia in 1991, followed by a postdoctoral fellowship with the Mineral Deposit Research Unit. He worked for 15 years as an independent consultant specializing in structural controls on ore deposits before joining Eldorado Gold Corporation in 2009 in his current position of vice president of exploration. At Eldorado, Peter is responsible for the technical oversight and strategic planning of the company's exploration programs, including project generation, early- to late-stage exploration projects, and mine site exploration.

**Russell Myers** is a mineral exploration consultant. After undergraduate studies in geology and geophysics at University of Missouri, Rolla, he obtained a Ph.D. degree in geology from the University of the Witwatersrand. He subsequently taught at the Key Center in Economic Geology at James Cook University. He has been involved in mineral exploration and structural controls on mineralization throughout his career. While working with AngloGold Ashanti, International Tower Hill Mines, and Corvus Gold over a 10-year period, he and his colleagues used oriented core extensively and, learning by making mistakes, developed robust methodologies for marking and QAQC of orientation lines, together with strategies for acquisition and analysis of structural readings. These oriented core structural readings were instrumental in developing real-time geologic models affecting drilling strategies in a variety of geologic settings.

**Michael Nugus** is a geoscientist with 25 years of practical and strategic experience in gold mining, project development, value generation, and more specifically, characterizing geologic controls on mineralization in deposits from Australia, Ghana, South Africa, Tanzania, and Colombia. Following more than 18 years in greenfields exploration and underground production,

## Biographies (continued)

his more recent focus is to create spatially and geologically based, predictive models for resource estimation, mineral processing, and optionality within strategic projects—in particular, Sunrise Dam, Obuasi, and Quebradonna. He is currently employed by AngloGold Ashanti as the principal economic geologist for the Strategic Planning and Technical Group.

**Nicholas (Nick) Oliver** is lead consultant and director within the Australian consortium HCOV Global and adjunct professor at James Cook University. He has a B.Sc. (Hons) degree from the University of Queensland (1981) and a Ph.D. degree from Monash University (1988). After positions with the Commonwealth Scientific and Industrial Research Organisation, Carnegie Institute Geophysical Laboratory, and Monash and Curtin Universities, he was professor of economic geology at James Cook University from 1997 to 2010, and director of the Economic Geology Research Unit. For the last 10 years he has been a full-time consultant to the minerals sector, focused on fusion of structural, geochemical, and geophysical data, centered on mapping and drill core analysis and training. He has broad commodity experience, from Au, Pb-Zn-Cu, rare earth elements, Fe, and U in Precambrian polydeformed metamorphic belts (particularly Australia, Fennoscandia, Brazil, and West Africa) to porphyry, epithermal, skarn, and other Mesozoic to Cenozoic systems in the Tethys, Mongolia, Southeast Asia, and South America.

**Leigh Rankin** holds a B.Sc. (Hons) degree in geology from the University of Adelaide (1983). He joined the South Australian Geological Survey in 1985 as a field geologist and subsequently joined World Geoscience Corporation (1994) as a senior geologist, where he was involved with major geologic projects in India and South America. In 1997, Leigh formed an independent consultancy specializing in the integration of structural geology and interpretation of geophysical data for mineral and hydrocarbon exploration, with involvement in programs in over 35 countries. He maintains a strong focus on training for both exploration and government survey geoscientists, conducts workshops and on-site collaborative programs in interpretation of magnetic data, and is a coauthor (with David Isles) of a book on this subject. He is a member of the Australian Institute of Geoscientists, the Society of Economic Geologists, and the Geological Society of America.

**David Rhys** is a consulting geologist based in Vancouver, Canada. He studied at the University of British Columbia and subsequently has worked since the early 1990s in the mining industry, applying geologic studies with a structural focus to exploration, development, and mining. Mr. Rhys has extensive experience in assessing ore controls on gold deposits, having worked globally on numerous gold districts for both major and junior companies, as well as evaluating districts containing volcanogenic massive sulfide, porphyry, and uranium deposits. His focus is on advanced projects and active mining operations, aiding in the interpretation of mine site ore controls and applications of mine geology to local and district-scale exploration activities, and the training of geologic teams.

**Julie (JR) Rowland** teaches structural and economic geology at the University of Auckland, New Zealand, where currently she is head of the School of Environment. JR started her career teaching physical education to high school students but caught the geology bug after returning to university to complete her B.Sc. (Hons) degree under the guidance of the wonderfully enthusiastic K. Bernhard Spörli. She then had the good fortune to undertake a Ph.D. degree with Rick Sibson, who inspired her to focus on tectonofluid interactions. JR is particularly interested in heat and mass transfer within extensional provinces and has worked in New Zealand, Ethiopia, Antarctica, and Chile.

**Ioan Sanislav** is an economic geologist and codirector of the Economic Geology Research Centre at James Cook University, Townsville, Australia. He obtained an M.Sc. degree (geology) from Alexandru Ioan Cuza University (2005) and a Ph.D. degree (geology) from James Cook University (2009). Ioan's main research interest is in economic geology, structure, and tectonics with a focus on exploration for mineral deposits, field geology, and geologic mapping, structural controls on mineralized systems, and the interplay between tectonic process and mineralized systems. His experience includes lode gold, iron oxide copper-gold, sedimentary exhalative, manganese, and chromitite deposits as well as epithermal and porphyry systems.

**James Siddorn** holds a B.Sc. (Hons) degree in geology from the University of Durham (1995) and an M.Sc. degree (1999) in geology and Ph.D. degree (2011) in structural geology from the University of Toronto. His Ph.D. work focused on the structural geology of the Giant and Con gold deposits, Yellowknife, Canada. From 1995 to 1996 he worked for Alexander Gibb and Partners as a geologist in Newcastle-on-Tyne, United Kingdom. He emigrated to Canada in 1996, where he also worked as a geologist for the Government of the Northwest Territories (1998–1999) and the Geological Survey of Canada (1999–2001). Since 2001 he has worked for SRK Consulting (Canada) Inc., focused on the application of structural geology to mineral exploration and mining, including the interpretation of aeromagnetic data applied to exploration. James has undertaken projects in Australia, North, South and Central America, Asia, the Middle East, India, and Africa, covering orogenic gold, epithermal, porphyry, volcanic-hosted massive sulfide, magmatic Ni-Cu-platinum group element, and sedimentary exhalative deposits. He has a detailed knowledge of orogenic gold, volcanic-hosted massive sulfide (in particular the Iberian pyrite belt), and magmatic Ni-Cu-platinum group element (in particular the Sudbury basin) deposits, as well as the regional- to deposit-scale controls on mineralization.

**Paul Stenhouse** is currently an independent structural geology consultant. He completed a B.Sc. (Hons) degree at the University of Otago in 2002 and a Ph.D. degree at The Australian National University in 2014. Paul worked as an exploration geologist for several precious and base metal exploration companies prior to his Ph.D. studies. After

## Biographies (continued)

his Ph.D. studies, Paul spent five years working as a senior consultant with SRK Consulting (UK) Ltd. During this time, he worked on a variety of commodities and deposit styles and contributed to mineral projects that ranged from greenfields exploration through to production. Since becoming an independent consultant in 2017, he has primarily worked on orogenic gold deposits throughout Africa and Australia.

**Margaret Stewart** is an assistant professor of geology at Mount Royal University in Calgary. Her research focuses on the relationship between plate tectonics, crustal-scale structures, and magmatic-hydrothermal mineralizing systems in modern and ancient arc and back-arc settings. She participates in scientific research cruises, and her current research area is the Lau basin of the southwest Pacific Ocean. She has a B.Sc. (Hons) degree in earth sciences with a minor in mathematics from Carleton University and a Ph.D. degree in mineral deposits and Precambrian geology from Laurentian University, and she recently completed a postdoctoral fellowship at the University of Ottawa.

**Richard Tosdal** received a bachelor's degree from the University of California, an M.Sc. degree from Queen's University, and a Ph.D. degree from the University of California at Santa Barbara. He worked for the U.S. Geological Survey (1978–1999) and was the director of the Mineral Deposit Research Unit at the University of British Columbia (1999–2008). He currently consults to the minerals industry on aspects regarding the metallogenic evolution of plate margins, the structural controls on ore deposition, and evolution of a range of hydrothermal deposits. He serves on technical advisory boards to junior mining companies, is active in facilitating industry designed research and development projects, and retains an adjunct appointment at the University of British Columbia.

**Gerard Tripp** holds a Ph.D. degree in structural geology and stratigraphy from James Cook University, an M.Sc. degree in the structural geology of gold deposits from Curtin University, and a B.Sc. degree in structural geology from the University of Technology in Sydney. Gerard is an industry consultant with over 25 years' experience in mineral exploration and mining on Archaean greenstone gold deposits, porphyry Cu-Au and epithermal deposits, sedimentary-hosted Cu deposits, and volcanogenic massive sulfide Cu deposits. He has worked extensively in Australia, Papua New Guinea, Africa, and Europe and consults globally to commodity explorers.

**Ron Uken** is principal consultant of structural geology with SRK Consulting in Vancouver, Canada. His specialization is in structural mapping and 3-D structural modeling of ore deposits. This includes the application of structural geology to exploration, mineral resource estimation, geotech, and hydrogeology. After completing his Ph.D. work on the structure of the Bushveld Complex aureole, Ron continued working in academia as economic geologist at the University of KwaZulu-Natal, South Africa. As a consultant, Ron has worked on a range of precious and base metal projects throughout Africa, the Middle East, and the Americas, offering structural geology support as well as working with site geologists assisting with mapping, data collection, logging, and structural interpretation.

**Peter Williams** holds B.Sc. (Hons) and Ph.D. degrees in geology and geophysics from the University of Tasmania, specializing in structural geology. He worked for 21 years in geologic mapping with Geoscience Australia and the Geological Surveys of Tasmania and Indonesia until 1993, when he joined a geologic consultancy that became part of SRK Consulting. He worked primarily on developing techniques for using structural geology as the basis to interpret aeromagnetic data and applying that to targeting for a variety of mineral deposits. He has applied this approach to major projects in Australia, Zambia, Democratic Republic of Congo, Vanuatu, Solomon Islands, Papua New Guinea, and West Africa. Peter was managing director of SRK in Australia from 1999 to 2010. Since 2012, Peter has worked on publishing results of aeromagnetic interpretation and targeting projects as adjunct associate professor at the University of Western Australia's Centre for Exploration Targeting, where the work for this contribution was carried out.