Aquat Geochem (2014) 20:81–86
DOI 10.1007/s10498-014-9229-8

ORIGINAL PAPER

# Preface to Owen P. Bricker III Special Issue of Aquatic Geochemistry

## Understanding Thermodynamic Relationships and Geochemical Mass Balances from Catchment to Coast: A Tribute to the Life and Career of Owen P. Bricker III

**Suzanne B. Bricker · Fred T. Mackenzie · Jill S. Baron · Jason R. Price**

Received: 21 February 2014 / Accepted: 22 February 2014
© US Government 2014

**Abstract** This special volume of aquatic geochemistry is dedicated to the memory of Owen Peterson Bricker III (1936–2011) and serves as a tribute to his life and career. Owen had a distinguished and productive research career in both academics at Johns Hopkins University (Fig. 1) and as a public servant with the Maryland Geological Survey, the US Environmental Protection Agency, and the US Geological Survey. He was a pioneer and leader in aqueous geochemistry, who applied a study approach that quantified mineral weathering reactions and equilibrium thermodynamic relations to better understand the chemical evolution of stream water in small watersheds. He will be especially remembered for his efforts to establish rigorous field studies in small catchments around the United States as a means of quantifying the sources of acid-neutralizing capacity that affect the chemical status and biological health of natural waters.

**Keywords** Thermodynamic relationships · Geochemical mass balances · Owen P. Bricker III

S. B. Bricker (✉)
National Oceanographic and Atmospheric Administration, Silver Spring, MD, USA
e-mail: Suzanne.Bricker@noaa.gov

F. T. Mackenzie
University of Hawai'i at Manoa, Honolulu, HI, USA
e-mail: fredm@soest.hawaii.edu

J. S. Baron
US Geological Survey, Fort Collins Science Center, Fort Collins, CO, USA
e-mail: jill_baron@usgs.gov

J. S. Baron
Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO, USA

J. R. Price
Millersville University, Millersville, PA, USA
e-mail: Jason.Price@millersville.edu

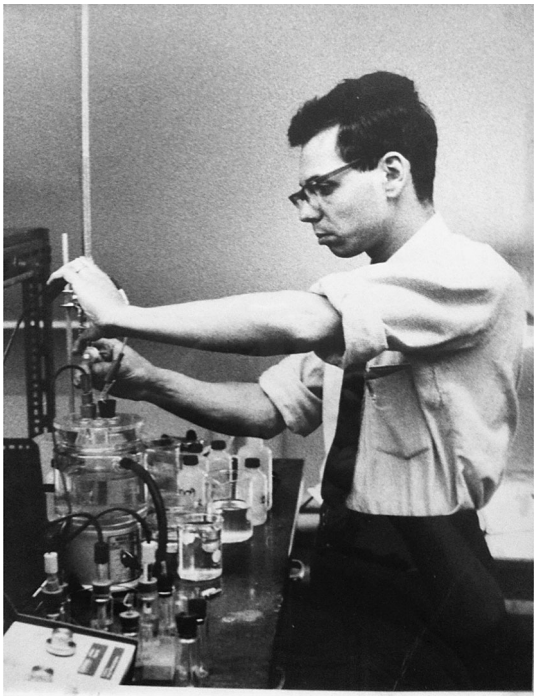

**Fig. 1** Owen in a Johns Hopkins University laboratory in the early years (~1965, note the tie!)

Long-term ongoing research programs in the Catoctin, Catskill, Georgia, Rocky Mountains, and other regions are a testament to the strength of the small-watershed mass-balance study approach and to the ability of Owen to find sources of financial support to develop and maintain these programs. Since these pioneering studies, small-watershed mass-balance methods have been extensively utilized by Owen's research team and others in studies of acid deposition, ecosystem dynamics, atmospheric $CO_2$ consumption attributable to chemical weathering, response times of clay minerals in regolith, and climatic and kinetic influences on mineral weathering rates, among others. He extended the mass-balance approach to examine the sources and fates of contaminants in estuaries, with a special focus on the Chesapeake Bay where he helped design and establish the Chesapeake Bay Program (Fig. 2). His work at the Maryland Geological Survey was the start of his tireless advocacy of the importance of long-term environmental monitoring. Owen had a strong interest in the use of science to inform public policy to help find solutions to environmental issues, an endeavor he pursued throughout his career. His research played a seminal role in US and international efforts to address acid rain, among other impacts, through interpreting research results as well as through activities with groups that he helped start such as the US National Acid Precipitation Assessment Program and the BIOGEOMON symposia. In the mid-1990s, he served the White House Office of Science and Technology Policy in an effort to establish a national environmental monitoring network.

Owen wrote or co-authored two edited books and more than 70 publications during his career. His early research using laboratory experiments to define the stability boundaries of manganese minerals in aqueous solution (Bricker 1965) has become a classic reference in the application of equilibrium thermodynamics to understand natural solution chemistry as a reflection of mineral–solution reactions. Owen followed this work with studies of the

**Fig. 2** Maryland Geological Survey Chesapeake Bay Earth Science Study (CBESS)—the early Chesapeake Bay Program (1977). The CBESS project team taking a break from laboratory work. *Right to left* Owen (*seated*), Jeff Halka, Eli Reinharz, Bob Cuthbertson, Bob Conkwright, Randy Kerhin, Janet Watson Barnhill, Bob McGrain, Greg Gunzleman (*bottom*), Bill McCafferty (*top*). Not pictured, Darlene Wells

dissolution behavior of silicates in seawater, and a little known but important investigation of the transport of Saharan dust to the Bermuda Islands. He and his co-author Fred Mackenzie (FTM) showed that the flux of this dust to the islands remarkably could account for the development and thickness of the Pleistocene red paleosols of Bermuda. During the course of this work, Owen also focused his attention on studies of sedimentary carbonates. Much of Owen's early carbonate work resulted from teaching and research activities in Bermuda at the Bermuda Biological Station for Research (BBSR) [now the Bermuda Institute of Ocean Sciences (BIOS)] with other pioneers in aqueous geochemistry, carbonate sedimentology, and paleobiology such as Bob Garrels, who served as his Ph.D. advisor, Roland Wollast, Bob Berner, Lynton S. Land, Steven J. Gould, Robert N. Ginsburg, FTM, and others. This work culminated with Owen and FTM organizing an international conference on carbonate minerals to assess the state of knowledge of carbonate cements and their mechanisms of formation in modern and ancient freshwater and seawater environments and in the subsurface. This activity resulted in the now classic and still often cited book *Carbonate Cements* (Bricker 1971). After spending several enjoyable and productive summers in Bermuda, Owen began to develop his research program focusing on small-watershed geochemistry. Two early landmark papers that resulted from this research were a Benchmark Paper in Hydrology and a Benchmark Paper in Geology, work that is considered foundational today in aqueous geochemistry courses and textbooks (Bricker et al. 1968; Cleaves et al. 1970). There is a recurrent theme of investigations into the geochemistry of Chesapeake Bay that continued throughout his career, and his publications from the 1970s into the twenty-first century reflect his ongoing interest in his native region.

Owen was inducted as a Fellow to the Geological Society of America, the Mineralogical Society of America, the Geological Society of London, and the American Association for

the Advancement of Science and won three USGS Honor awards during his career. He was also a member of the Cosmos Club of Washington, DC, a social club for distinguished members of the scientific, literary, and artistic communities. He was passionate about teaching, and he was unfailingly generous with his time and ideas. He mentored many young students and early career scientists, as seen in his publication list which includes many papers co-authored by (then) young scientists. For at least one of us serving as Guest Editor (JSB), Owen was an inspiring mentor for whom the wonder of natural science and field work endured. From helping to install a Parshall Flume in the remote Loch Vale watershed of Rocky Mountain National Park using picks and shovels (which took 1 month and included a daily 4-mile hike), to guidance on data interpretation, and to offering his daughters as summer field help, Owen instilled the gift of discovery and hard work that is hopefully being passed on to new students. Many of the students he mentored, as well as colleagues and professional associates, who were influenced by him, have gone on to notable careers as research scientists at USGS and elsewhere. Owen will be remembered as a kind and genteel person, quiet and unassuming, but whose reach of influence was extensive. A good illustration of Owen's influence and generosity is the first interaction with another of the Guest Editors (JRP), then a PhD student, at the 2001 Goldschmidt Conference. He provided numerous thoughtful insights then and throughout JRP's watershed mass-balance dissertation project. The interaction continued after JRP joined the faculty at a university with close access to the Catoctin Mountain watershed site in Maryland. As he transitioned to retirement (Fig. 3), Owen provided JRP with extensive data sets, as he had done for others throughout his career, and enthusiastically encouraged and supported continued research at the Catoctin Mountain site where he had conducted extensive small-watershed studies. Many of us who worked with him became lifelong friends. He loved the outdoors, including hunting, fishing, and hiking, and he was an excellent marksman. He is survived by his wife Anne (Fig. 4), three daughters, Amy, Suzanne, and Emma, and their families, including seven grandchildren. He was preceded in death by his daughter, Katherine. His daughter Suzanne was inspired to pursue a career in coastal and ocean science after spending exciting formative summers living at the Bermuda Biological Station. Her focus on estuaries resulted from being part of the extended family that conducted the Chesapeake Bay Earth Science Study, the early Chesapeake Bay Program. She continues his legacy as a research scientist at the National Oceanic and Atmospheric Administration.

This special issue highlights the breadth and importance of Owen P. Bricker's work and shows his continuing legacy through new work. The volume includes 13 papers by 26 authors and co-authors from two US federal agencies (USGS and NOAA) and nine universities (eight US and one German). Topics span the breadth of Owen's career and interests from carbonate geochemistry to watershed weathering processes to estuarine sedimentation processes and eutrophication. Study locations are equally diverse both in location and size, ranging from individual small mountain watersheds to the scale of the global ocean. Methods used to help understand factors leading to observed conditions and for predicting potential changes, range from laboratory-scale experiments to long-term observations to the construction and use of models. A tribute to the continuing usefulness of the small-watershed concept is that the majority of papers (9) in this volume describe small-watershed research in locations from Hawaii (De Carlo et al. 2014) and Puerto Rico (Stallard and Murphy 2014) to Wisconsin (White 2014) and Colorado (Heath and Baron 2014), from Georgia (Peters et al. 2014) and North Carolina (Price and Velbel 2014) to Maryland (Rice and Price 2014; Price and Szymanski 2014) and Virginia (Busenberg and Plummer 2014). These small-watershed mass-balance studies investigate weathering

**Fig. 3** Owen's retirement party (April, 2007). Owen (*seated in middle*) is surrounded by his loving family [wife, Anne (*second row left)*; daughter Suzanne with grandson, Peter; son-in-law, Peter Wiley (*front*); sister-in-law and husband (*back row left*)], good friends (*front right*), colleagues [*left to right* Ken Weaver and wife, Wayne Newell and wife, Niel Plummer and wife, Jim Manning and wife (*far right*), and Karen Rice], and his beloved dogs, Sophie and Piri

**Fig. 4** Owen and his wife, Anne on vacation in Scotland (early 2000s)

processes to better understand the impacts of pollution, deforestation, and climate change on these environments and thus to help find solutions to these environmental concerns. Two estuarine studies investigate the influence of headwaters on water quality and the feasibility of using shellfish aquaculture as a complement to current nutrient management (Bricker et al. 2014) and evaluate the importance of estuarine sedimentation processes on the global carbon budget (Zhu and Olsen 2014). A global-scale study uses models to investigate the global C cycle and the effect of ocean–atmosphere–sediment coupling on atmospheric $CO_2$ concentrations (Arvidson et al. 2014). The final paper evaluates the progress of an integrated research and monitoring program introduced by Owen and others

at the Office of Science and Technology Policy, with recommendations for continuing collaboration among research, monitoring and resource management communities to provide strong scientific support for environmental policy decisions (Murdoch et al. 2014). Together, these papers and the continuing research they represent provide a rich foundation and are reflective of the continuing legacy of Owen P. Bricker III.

## References

Arvidson RS, Mackenzie FT, Berner RA (2014) The sensitivity of the Phanerozoic inorganic carbon system to the onset of pelagic sedimentation: Aquat Geochem. 20:343–362

Bricker OP (1965) Some stability relationships in the system Mn–$O_2$–$H_2O$ at 25 °C and one atmosphere total pressure. Am Mineral 50:1296–1354

Bricker OP (1971) Carbonate cements, studies in geology no. 19, Johns Hopkins University, Baltimore, MD, 376p

Bricker OP, Godfrey AE, Cleaves ET (1968) Mineral-water interaction during the chemical weathering of silicates. In: Gould RF (ed) Trace Inorganics in Water, Advances in Chem Ser, 73, Amer Chem Soc, Washington DC, pp 128–142

Bricker SB, Rice KC, Bricker OP (2014) From headwaters to coast: influence of human activities on water quality of the potomac river estuary. Aquat Geochem. 20:291–323

Busenberg E, Plummer LN (2014) A 17-year record of environmental tracers in spring discharge, Shenandoah National Park, Virginia, USA: implications for climatic and environmental change. Aquat Geochem. 20:267–290

Cleaves ET, Godfrey AE, Bricker OP (1970) Geochemical balance of a small watershed and its geomorphic implications. Geol Soc Am Bull 81:3015–3032

De Carlo EH, Tomlinson MS, deGelleke LE, Thomas S (2014) Distribution and abundance of arsenic in the soils and sediments of O'ahu, Hawai'i. Aquat Geochem. 20:87–113

Heath J, Baron J (2014) Direct and indirect effects of climatic drivers on the mass balance of a mountain watershed. Aquat Geochem. 20:167–181

Murdoch PS, McHale M, Baron J (2014) Reflections on a vision for integrated research and monitoring after 15 years. Aquat Geochem. 20:363–380

Peters NE, Burns DA, Aulenbach BT (2014) Evaluation of high-frequency mean streamwater transit-time estimates using groundwater age and dissolved silica concentrations in a small, forested watershed. Aquat Geochem. 20:183–202

Price JR, Szymanski DW (2014) The effects of road salt on stream water chemistry in two small forested watersheds, Catoctin Mountain, Maryland, USA. Aquat Geochem. 20:243–265

Price JR, Velbel MA (2014) Rates of biotite weathering, and clay mineral transformation and neoformation, determined from watershed geochemical mass-balance methods for the Coweeta Hydrologic Laboratory, Southern Blue Ridge Mountains, North Carolina, USA. Aquat Geochem. 20:203–224

Rice KC, Price JR (2014) Comparison of mineral weathering and biomass macronutrient uptake in two small forested watersheds underlain by quartzite bedrock, Catoctin Mountain, Maryland, USA. Aquat Geochem. 20:225–242

Stallard RF, Murphy SF (2014) A unified assessment of hydrological and biogeochemical responses in research watersheds in eastern Puerto Rico using runoff–concentration relations. Aquat Geochem. 20:115–139

White AF (2014) Chemical weathering of Pleistocene glacial outwash sediments: a comparison of contemporary and long-term rates for soils and groundwaters. Aquat Geochem. 20:141–165

Zhu J, Olsen CR (2014) Sedimentation and organic-carbon burial in the Yangtze River and Hudson River estuaries: implications for the global carbon budget. Aquat Geochem. 20:325–342