



Perspective

A remembrance of Steve Banwart (1959–2023)

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Steve Allan Banwart, Professor and Director of the Global Food and Environment Institute at the University of Leeds passed away on December 30th, 2023. Steve held the Leadership Chair in Integrated Soil-Agriculture-Water Research since 2015 when he joined the faculty of the University of Leeds, where he was the founding Director of the Global Food and Environment Institute and Dean for Global Development.

Steve was born in Burlington, Iowa and was raised on a dairy farm near Mediapolis, Iowa. He graduated from Mediapolis Community High School in 1977. He attended the University of Iowa graduating with a BSc in Civil Engineering in 1981 and completing his MSc in Environmental Engineering in 1983. He joined the Von Karman Institute for Fluid Mechanics in Belgium for a year and then the Swiss Federal Institute of Technology (ETH) – Zurich where he received his Post-

Graduate Diploma in 1985 and his PhD in 1989 under the supervision of Prof. Werner Stumm.

He was a post-doctoral research associate and then an industry research fellow at the Department of Inorganic Chemistry at the Royal Institute of Technology, Stockholm, Sweden from 1989 to 1995 before he was appointed as Lecturer in Environmental Engineering in the Department of Civil and Environmental Engineering at the University of Bradford (1995–1997). Subsequently, he moved to the Department of Civil and Structural Engineering at the University of Sheffield, starting as a Senior Lecturer (1998–2001), Reader (2001–2002) and Professor of Environmental Engineering Science (2002–2015). From 2009 to 2012, Steve held the position of Director of Research and Innovation on Energy and Environment and from 2009 to 2014 he was the Director of the Kroto Research Institute at the University of Sheffield. While at the University of Sheffield, Steve served as Secretary of the European Association of Geochemistry from 2008 to 2012. In 2016, he moved to the University of Leeds, serving in various positions before his untimely passing in 2023.

In founding the Global Food and Environment Institute at Leeds, Steve envisioned “*a radically different global food system which works with nature and provides everybody with access to safe and nutritious food. The aim is to develop enduring solutions that help bring about transformative change to create a food system that is socially-just, climate-smart and goes beyond sustainability; able to adapt vigorously to enhance the future habitability of our planet*”. Steve fostered disruptive thinking in developing innovative solutions where new scientific ground is broken through

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multidisciplinary collaboration.

One of Steve's many abilities, enabled though his charisma, was to build bridges and establish collaborative international programs. He successfully brought together people from different disciplines at the University of Leeds to establish the Global Institute for Food and Environment and at the global level through strategic partnerships with China, Africa and the US. This is an impressive record that was recognized by the University of Leeds in appointing him to the position of Dean for Global Development.

Steve throughout his career exhibited outstanding global leadership in tackling the linked global challenges of environmental sustainability and food security. He has left a mark on every environmental issue he has worked on. He has made exceptional scientific contributions in soil and groundwater chemistry, cell-mineral interface research, mine water pollution, nuclear disposal research, and processes at the mineral-water interface.

Contribution in Soil and Groundwater Chemistry (Critical Zone Science) - Steve's main research focus has been in the area of Critical Zone Science, in which he has worked for the past 20 years, and in particular soil and groundwater chemistry. He has followed a holistic multidisciplinary approach of laboratory, field and modeling studies. Steve was instrumental in "bringing" critical zone science to EU and building the scientific bridges between US and EU on this topic. His contribution on soil science has significant implications to agricultural development and restoration of degraded soils (Banwart et al., 2014, 2019; Horton et al., 2021). He was appointed the Chair of SCOPE for an international rapid assessment process project on Benefits of Soil Carbon and a Commissioned Comment on soil sustainability published in Nature (Banwart, 2011). His work on critical zone science was summarized in two invited critical reviews on soil sustainability in the Annual Reviews of Earth and Planetary Science and in Global Change Biology.

From 2003 to 2006, Steve worked through and attended a series of international multidisciplinary (most focused in geochemistry) meetings aimed at broadening participation and asking a set of driving questions that would underpin the development and formalization of critical zone science. In 2007, Steve was awarded and co-led the first formally funded project in the realm of critical zone science, the EU-funded SoilCritZone project, at a time when national science foundations were jockeying to establish this nexus in Earth surface and environmental science research. The project involved a series of scoping meetings to determine the aims and directions of critical zone science in Europe. In short order, the US NSF (2007/8) followed not long after by the EU in early 2010 established formally-funded programs with networks of study sites called critical zone observatories – Steve was the PI for the EU SoilTREC project. Steve was primary author of the final report "Sustaining Earth's Critical Zone" in 2013, an influential document that arose from an international meeting of critical zone scientists at the U of Delaware in 2011. When the SoilTREC project culminated in 2015, Steve led the successful effort to build a joint UK-China critical zone observatory program. His international influence in critical zone science continued through graduate and post-graduate summer schools established through Belmont Forum projects.

In recent years, Steve led primary research with significant contribution to climate change research on enhanced rock weathering for large-scale CO₂ drawdown that was published in Nature, Nature Climate Change, Nature Plants, Nature Geosciences (Taylor et al., 2016; Beerling et al., 2020; Kantzas et al., 2022). These publications simply highlight Steve's many activities in the name of critical zone science. Steve's selfless leadership through this time was instrumental in the success of establishing a new realm and approach in science. Steve attended critical zone science meetings, workshops, and trainings in Europe and Africa, the US, Australia, China, and Brazil – the international community relied on him heavily to well represent the science which he accomplished with energy and enthusiasm, gaining a long list of friends through the process.

Contribution in Cell-Mineral Interface Basic Research - Steve

conducted basic research at the cell-mineral interface with major contributions in the area of cell attachment to mineral surfaces. He established a biological imaging capability for biodegradation and colloid transport in porous media and successfully applied parallel processing computational methods to simulate fermentation-respiration dynamics in polluted groundwater. His work was featured in an invited perspectives article for Bulletin of the WHO on soil and groundwater pathogen mobility and human health (Bridges et al., 2010; Baud et al., 2017; Zhu et al., 2018).

Contribution in Mine Water Pollution - While at the University of Sheffield, Steve made significant contribution in the area of mine water pollution by developing a kinetic model to assess mine water pollution as well as a novel framework for source term modelling in risk assessment of mine water pollution. His work was summarized in a research textbook that he co-authored.

Contribution on Geological Disposal of Spent Nuclear Fuel - Early in his professional career at the Royal Institute of Technology in Sweden, Steve led a group of scientists that conducted seminal field studies on groundwater redox conditions linked to repository safety as well as laboratory studies on the redox geochemistry of the geological barrier and the implications for repository performance and safety (Banwart et al., 1997). He was a Co-I of an EPSRC consortium on nuclear science and technology and on EPSRC DTC for Fission Innovation, Research, Science and Technology. His work was presented in a feature article on international disposal of spent nuclear fuel, including a review of the authors' research.

Contribution on Processes at the Mineral-Water Interface - Steve's doctoral research with Werner Stumm focused on the reductive dissolution of hydrous iron(III) oxides. Steve published four papers on this topic between 1989 and 1991 – all four papers have been cited more than 100 times and continue to be cited to this day (Afonso et al., 1990; Banwart et al., 1989; Sulzberger et al., 1989; Suter et al., 1991). In his work, Steve compared the reactivities of hematite and goethite, examined the effectiveness of organic reductants such as ascorbate and dissolved complexes of iron(II) with oxalate, and explained the pH-dependent effects of aluminum on ascorbate-promoted dissolution. This continuing relevance of this work is a tribute both to the choice of environmentally-relevant model systems, including geologically-abundant and biologically-important iron(III) oxides and simple organic acids that are present in many soil systems, and the interpretation of experimental results based on a coherent concept for surface-complex formation.

Steve has been extremely prolific in his career. He has authored 3 books and monographs, 31 edited books and more than 165 publications in refereed journals. His work was highly cited (more 7400 citations in SCOPUS) with an H-Factor of 50.

Steve's career has been extraordinary, from the floodplains of Mississippi, to University of Iowa to Europe and to Dean for Global Development at the University of Leeds. The Geochemistry community will remember Steve for his service and contributions as member of the Council and Secretary of the European Association of Geochemistry and as Chair of the Earth Surface Geochemistry Section of IAGC. His colleagues and friends will remember Steve for tireless efforts to contribute to the solutions of grand societal challenges and his love of working with people across disciplines by creating global partnerships. He will be missed.



Most significant research contributions.

CRediT authorship contribution statement

Nikolaos P. Nikolaidis: Conceptualization, Writing – original draft, Writing – review & editing. **Janet Hering:** Writing – original draft, Writing – review & editing. **Timothy S. White:** Writing – original draft, Writing – review & editing. **François Chabaux:** Writing – review & editing. **Orfan Shouakar-Stash:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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