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Geochimica et Cosmochimica Acta 71 (2007) 5579–5582
Geochimica et Cosmochimica Acta
www.elsevier.com/locate/gca

Editorial

Physical chemistry of soils and aquifers: A special issue in honor of Garrison Sposito

This special issue of GCA has been organized in honor of Professor Garrison Sposito (University of California at Berkeley), whose ongoing career has engendered a rigorous and multi-faceted approach to the geochemistry of the Earth's land surface, particularly soils and shallow ground-water environments. The group of papers contained herein is an outgrowth of a four-day-long symposium entitled "Physical Chemistry of Soil and Aquifer systems: A Symposium in Honor of Garrison Sposito," which was co-sponsored by the Geochemistry, Environmental Chemistry, and Colloid & Surface Chemistry Divisions of the American Chemical Society during the Fall 2006 Annual Meeting in San Francisco (CA, USA) (Fig. 1). The motivation for both the symposium and this special issue is to celebrate the fact that for several decades Gary has been a leader in adapting advances in physical and analytical chemistry, particularly molecular spectroscopy and modeling, to elucidate geochemical processes in soils and aquifers. Such a pursuit is important not only because these systems are amongst the most fascinating and complex on the planet, but also because they impact directly the capacity of the Earth to provide food and water to a growing population. In this sense, the school of thought that Gary has helped to nurture is defined by the determination to apply the most rigorous scientific approach to the most complex natural systems.

Sposito (1989) defines soils as "*multicomponent, open, biogeochemical systems containing solids, liquids and gases*" that are "*derived from biological, geological and hydrologic phenomena*". Given this complex mileux, the challenge of deducing chemical reaction mechanisms is apparent. Indeed, Gary has always been a proponent of the notion that soils and other complex geomedia may be studied with the same methods that physical chemists use to probe "simpler" systems. He is perhaps best known for the many textbooks wherein he has laid the foundations for applying modern thermodynamics, kinetics and molecular methods to understand the chemistry of soils and sediments. In addition to his pedagogical contributions, he is amongst the world's leading scientists in applying both experimental and computational tools to unravel the surface geochemistry of natural particles, as is documented in many of his more than 300 scientific journal publications. For example, he pioneered the use of in situ infrared spectroscopy to probe cation coordination at the soil particle–water interface (e.g., Sposito and Anderson, 1975; Sposito and Prost, 1982). He has continued to pursue this problem experimentally through vital collaboration with students and scientists, exploiting emergent methods, such as extended X-ray absorption fine structure spectroscopy (EXAFS), that can be applied to increasingly complex biogeochemical systems (Toner et al., 2006).

Gary completed his Ph.D. in Soil Science at the University of California at Berkeley in 1965, with a thesis entitled "On the General Theory of the Clay–Water Interaction". (Since he had been at Berkeley for only 22 months, he had to file a petition requesting a waiver of the University's two-year residency requirement for Ph.D. students.) At the time, there were few jobs in the area of soil physical chemistry, so he accepted a position in the Physics Department at Sonoma State University, where he pursued independent research in theoretical physics while handling a heavy course load, sometimes as many as five courses per semester. Indeed, he published nearly 20 papers during his time in a department that was largely dedicated to undergraduate teaching. The courses he taught there provided him with the motivation to write textbooks on quantum physics (Sposito, 1970) and classical dynamics (Sposito, 1976) that remain available and have received significant use in advanced physics courses over the years. (The books are used in senior or first-year grad courses.) His contributions to the teaching program in Physics garnered him the California State University Distinguished Teaching Award in 1970.

He returned to his roots in soil science in 1974 when he joined the Department of Soil and Environmental Sciences at the University of California, Riverside. It was at UC Riverside that Gary wrote *The Thermodynamics of Soil Solutions* (Sposito, 1981) and *The Surface Chemistry of Soils* (Sposito, 1984), which remain among the most influential graduate-level texts in soil chemistry. Their concise and rigorous conceptualization of chemical processes in heterogeneous soil systems represents what has become the signature of Gary's textbook contributions. His approach

0016-7037/$ - see front matter
doi:10.1016/j.gca.2007.09.010

Fig. 1. Participants of the symposium entitled, "Physical Chemistry of Soil and Aquifer systems: A Symposium in Honor of Gary, eyes closed in quiet forbearance," at the Fall 2006 Annual Meeting of the American Chemical Society in San Francisco (CA, USA). Garrison Sposito is in the center of the right half of the photograph.

in the classroom is quite similar, in fact. He is one of those few professors who can give a thorough lecture at the blackboard, replete with derivations, without using any notes. His teaching style is nonetheless fluid and accessible, and this certainly contributed to his receiving a second distinguished teaching award, this time from the University of California. He is believed to be the only person ever to have received distinguished teaching awards from both of the state university systems in California. While at UCR, Gary initiated his thermodynamic experimental studies of binary and ternary cation exchange on clay minerals and soils (Sposito et al., 1983). During his time at UCR, Gary's students were also involved in establishing analytical and computational methods for applying surface complexation models to complex natural soils (Goldberg and Sposito, 1984; Charlet and Sposito, 1987).

In addition, Gary had joined the UC Riverside department at a time of emergent concern over the use of sewage sludge as a soil amendment in arid lands. He conducted seminal experiments that quantified metal partitioning to soil solids and highlighted the important role of humic substances derived from these waste materials themselves (Sposito et al., 1982). This research initiated Gary's long-term interest in the structure and function of humic substances, which included close collaborations with Ken Hotzclaw and Nikola Senesi (Fig. 2) among others, and which has continued to evolve our understanding of these polydisperse mixtures of aggregated biomolecular fragments and degradation products that play such a central role in environmental geochemistry (Sutton and Sposito, 2005).

Gary moved to Berkeley in 1988, where he currently holds a joint appointment in the Department of Environmental Science, Policy and Management, and the Department of Civil and Environmental Engineering. At Berkeley he has authored three new textbooks in soil chemistry, including his undergraduate text, *The Chemistry of Soils* (Sposito, 1989, 2nd edition now in press), *Chemical Equilibria and Kinetics in Soils* (Sposito, 1994), and *The Surface Chemistry of Natural Particles* (Sposito, 2004). Re-

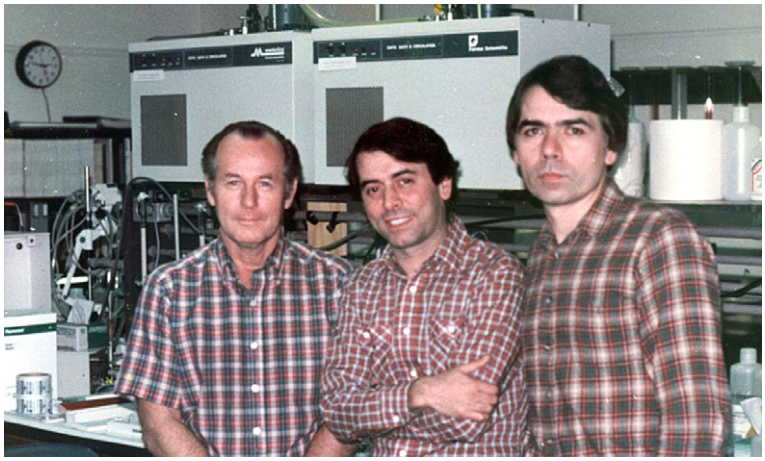

Fig. 2. Ken Hotzclaw, Nikola Senesi and Gary Sposito (left to right) at UC Riverside in 1983.

search in his Berkeley lab has maintained its principal foci on surface and colloid chemistry of soils, and it exploits consistently the new developments in both computational power and molecular spectroscopic methods as essential complements to macroscopic studies. His group's work on molecular dynamics simulations of cation adsorption and exchange (Sposito et al., 1999) are a case in point. Such studies have provided a unique capability to envision the nature of ion coordination at particle interfaces and indeed have moved us toward "*thinking in terms of images*" in respect to such processes and the tools for their measurement. At the same time, his group increasingly focused on complex interactions between microorganisms and minerals, applying advanced spectroscopic techniques and principles of chemical kinetics and thermodynamics (Chorover and Sposito, 1995; Hersman et al., 1995; Cheah et al., 2003; Toner et al., 2006).

A self-described experimentalist, Gary is also among our most valuable theoreticians. As a strict adherent to the dictum "*we only know what we measure*", his interpretations of experimental data are highly reliable. However, he teaches not only the dangers of data over-interpretation, but also the careful imposition of model constraints and the elimination of unjustified assumptions (Sposito, 1983, 1998). In his ACS talk, Sposito (2007) quoted Igor Stravinsky: "*The more constraints one imposes, the more one frees oneself of the chains that shackle the spirit . . . the arbitrariness of the constraint only serves to obtain precision of execution*".

It is worth noting that the ACS symposium and this special issue of GCA both focus on the "geochemical side" of Gary's career. There are other sides entirely. He is highly regarded and has received numerous awards—including the American Geophysical Union's prestigious Horton Medal (2004)—for his theoretical contributions to mathematical models of transport processes in porous media. He has made contributions to applied sciences and engineering, as evidenced by his concurrent appointments at Berkeley. He has worked on epistemological problems in social sciences (Sposito, 1969) which continues to contribute to discussions in internet blogs on the sociology of conflict resolution, and currently co-teaches a course in intropductory Environmental Studies with former U.S. Poet Laureate Robert Hass that focuses on the interface between humanities and science. It deeply impressed the authors of this editorial that Gary pursues all these intense and diverse research interests while making his family (see Gary with two of his four daughters in Fig. 3) his highest priority.

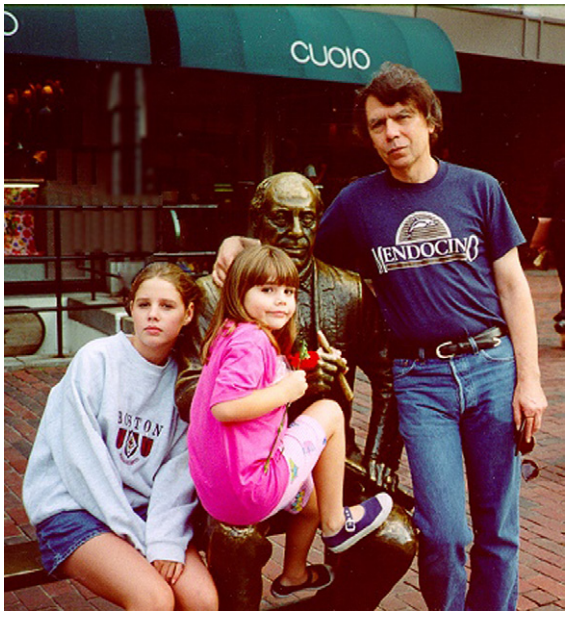

Fig. 3. Gary with daughters Sara and Cristina in Boston (1996).

The papers contained within this special issue are only a relatively small fraction of the many excellent research projects, from across different geochemical sub-disciplines and from across the international community, that were presented in San Francisco. However, the symposium in San Francisco and this special issue are intended to provide a glimpse of Gary's profound intellectual influence on the scientific community. Many of the authors have collaborated with Gary and all have been inspired by his work and his teaching.

The symposium organizers wish to thank all of our many friends—old and new—who gathered together in San Francisco to share new science and to "*celebrate the depth and breadth of Gary's continuing work.*" We also wish to thank the editor and associate editors of GCA who worked so hard to make this special issue possible, along with the dedicated reviewers. Finally, we thank Gary Sposito for the years of diligent work and insight; the careful mentoring sprinkled with Gary's special blend of panache; and for graciously honoring all of us through this opportunity to share a small portion of his 'school of thought' with the broader geochemical community.

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Received 6 September 2007;
accepted in revised form 18 September 2007
Available online 25 September 2007
Associate editor: Frank A. Podosek

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