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# STEPHEN GUGGENHEIM

## 2013 RECIPIENT OF THE MARILYN AND STURGES W. BAILEY DISTINGUISHED MEMBER AWARD

The following introduction was made on behalf of the recipient at the 50th Anniversary Annual Meeting of The Clay Minerals Society held at the University of Illinois at Urbana-Champaign, on October 8, 2013, by:

JOHN RAKOVAN

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Ladies and gentlemen, it is a great honor to introduce Professor Stephen (Steve) Guggenheim from the Department of Earth and Environmental Sciences of the University of Illinois at Chicago for the 2013 Marilyn and Sturges W. Bailey Distinguished Member Award. Steve is internationally recognized as one of the leading crystallographers and mineralogists whose research has focused on the structure and crystal chemistry of layer silicates.

Steve received his B.S. in Geology from Marietta College, Marietta, Ohio, in 1970 and his M.S. in Geology from the State University of New York at Stony Brook in 1972, where he worked on X-ray diffraction of heat-treated lunar pigeonites under the supervision of J.J. Papike. From there Steve went on to the University of Wisconsin-Madison to work on cation ordering in subgroup symmetry in the micas with Sturges 'Bull' Bailey for his Ph.D. His dissertation laid the foundation for an eminent career in clay mineralogy, which continues today. It is very fitting that at this, the 50th Anniversary Annual Meeting of The Clay Minerals Society, Steve is given the highest honor of the Society, which bears the name of his Ph.D. advisor and mentor.

Steve has been the recipient of other honors for his work in clay mineralogy, including the Hawley Medal of the Mineralogical Association of Canada in 1986; the Clay Minerals Society Marion L. and Chrystie M. Jackson Mid-Career Clay Scientist Award in 1994; the AIPEA Medal for Research Excellence for 2005–09 from the Association Internationale pour L'Etudes des Argiles (International Association for the Study of Clays); he is an elected fellow of the Mineralogical Society of America; and elected foreign member of the Accademia Nazionale dei Lincei (Italian Academy of Sciences and Humanities). He has also served as Editor-in-Chief of *Clays and Clay Minerals*, and was the President of The Clay Minerals Society from 1996 to 1997.



Over the last 25 years Steve has made major contributions in diverse areas of clay mineralogy including crystal-structure studies of phyllosilicates from X-ray diffraction data; transmission electron microscopy (TEM) characterization of modulated layer silicates; dehydration and dehydroxylation reactions; interactions between organic molecules and clays; and most recently, the intercalation of gas hydrates and clay minerals. The results of his work have been published in over one hundred peer reviewed journal articles and thirteen book chapters. Steve has also co-edited several books including *Baseline Studies of the Clay Minerals Society Source Clays*; *Micas: Crystal Chemistry and Metamorphic Petrology*, Reviews in Mineralogy and Geochemistry; and *Teaching Clay Science*, The Clay Minerals Society Workshop Lectures Series.

Some of Steve's most significant contributions have related to phyllosilicate crystal structures. In his earlier



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studies, in collaboration with S.W. Bailey, Steve and Bull developed models of cation ordering in subgroup symmetries for mica minerals such as margarite and zinnwaldite. The idea that ordering effects could only be recognized by considering subgroup symmetries of the space groups was novel, and they were the first to develop techniques where subgroups could be tested. Later, Steve focused on the structural behavior of phyllosilicates at high temperatures with seminal findings about the mechanisms and pathways involving how a wide range of interlayer-cation exchanged smectite minerals dehydrate and dehydroxylate. This work, with A. F. Koster van Groos, included the novel combination of high-temperature X-ray diffraction and high-pressure differential thermal analysis (DTA) which allowed for the development of atomistic models for these reactions, in addition to the description of their thermodynamic properties. During the same period, Steve and his students conducted high-temperature studies of the atomic structure of muscovite, phlogopite, lizardite, and chlorite to understand how phyllosilicate structures respond to temperature increases. Their work on muscovite was seminal in the use of Pauling's rules to develop an atomistic dehydroxylation model, which was later used by others to develop models for the dehydroxylation of *cis*-vacant micas.

Some of his analytically most challenging work has involved structural studies of complex modulated layer silicates, which give us insight into the topological limits and possible chemical variations of common layer silicates. This work emphasized the use of high-resolution transmission electron microscopy and electron diffraction. Steve developed structural models that allowed the prediction of which phyllosilicate structures were likely candidates for structural modulations. In addition, he helped to develop a general classification scheme for these complex structures. Much of this work was done in the 1980s with Tony Eggleton, long before most workers (at least in the West) recognized that structures could be obtained from TEM intensity data.

In his work on the interstratification of organic molecules in vermiculite, Steve took a systematic approach in studying both the atomic structure of the organic molecule and the clay mineral, and elucidated the effects of organic-molecule size and complexity on the clay mineral structure. He also showed that structural defects play an important role in how organic molecules interact in certain clays, such as palygorskite.

Steve's most recent research, and I think some of the most exciting and potentially significant, encompasses clay-hydrate intercalates and liquid-gas-solid interactions involving clay minerals under deep-ocean conditions and bore holes, using a high-pressure environmental chamber that Steve and A. F. Koster van Groos developed. These studies may have very important implications for our understanding of natural methane storage in clatherates and mineral influences on ocean water chemistry.

Steve is not only a highly accomplished scientist, he is also an exceptional teacher and thoughtful mentor, and I feel very fortunate to have had the opportunity to work with Steve for my M.S. degree. Considering the breadth and significance of Steve's contributions to the science of clay mineralogy, he is most deserving of this award.

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