

## Clara Brink Shoemaker (1921–2009)



Clara Brink Shoemaker, senior research professor emeritus at Oregon State University, died peacefully in her sleep of liver cancer at home in Corvallis, OR, 30 September 2009. Born in Rolde, The Netherlands, in 1921, she entered the University of Leiden in 1938 planning to major in chemistry with a minor in physics. The occupation of Holland in 1940 by armies of the Third Reich had relatively little initial effect on student life. The following year, however, her university was shut down after a student strike, although not before she was able to complete her Candidate's degree after 3 years of academic study. Utrecht University remained open where she was able to enroll while resuming her academic studies with Anton Eduard van Arkel in Delft, receiving her doctorate in chemical crystallography in 1950. She also worked one day each week with Caroline MacGillavry in Amsterdam where she learned crystallography. This led to the solution and publication of the crystal structures of  $K_2AgI_3$  and  $K_2CuCl_3$ .

Clara left Holland in 1950 to work with Dorothy Hodgkin on Vitamin B12 in Oxford where her contributions resulted in three papers coauthored by Dorothy and others. After her return to Leiden in 1951, she was encouraged both by Caroline MacGillavry and Dorothy Hodgkin to consider further postdoctoral experience. Their top choices for her were CalTech or MIT. Each wrote letters of recommendation both to Linus Pauling and David Shoemaker. Possibly influenced by having a niece living in Boston who was married to Nicholaas Bloembergen, a faculty member in Harvard's Physics Department and subsequent 1981 Nobel Prizewinner, she chose MIT. One of us (SCA) was staff member at that time in Arthur von Hippel's MIT Laboratory for Insulation Research and first met her shortly after her arrival in 1953. Crystallography was then well represented at MIT, by such major figures as Martin Buerger and Bertram Warren, both of whom warmly welcomed Clara.

Her collaboration with David, who had earlier recognized the importance of intermetallic compounds containing transition elements such as the  $\sigma$ -phase in both the iron–

chromium and other systems that he had investigated while at CalTech and had reported in *Acta Cryst.* in 1954, led to their first joint study. The resulting paper, published in *Acta Cryst.* the following year, established the  $\sigma$ -phase as typifying a promising new field. In August of that year, Clara and David's growing friendship culminated in marriage. The wedding ceremony took place in the MIT chapel, with her niece as Matron of Honor and Nicholaas giving the bride away. Their son Robert was born the following year.

Clara and David were the first to recognize that interstices in tetrahedrally close-packed metal crystals are exclusively tetrahedral, with coordination types restricted to a set of four having coordination numbers 16, 15, 14 and 12. They also noted that half the hexagonal holes present in  $\sigma$ -phase materials become distorted pentagons in the  $P$ -phase, resulting in a coordination number reduction from 14 to 12 in half the atoms of the subsidiary layers. They also discerned a further difference between  $P$ - and  $\alpha$ -phase structures, namely the larger proportion ( $\frac{1}{2}$ ) in the former *versus*  $\frac{3}{7}$  with 12-fold coordination in the latter, resulting in slight distortions from regular icosahedra.

Many contributions to this new field of intermetallic structure followed as a consequence, including a major paper by Linus Pauling in 1988 on icosahedral cluster  $\sigma$ -phase packing that acknowledged their early work. Among them are numerous X-ray and neutron diffraction studies by others together with some very recent modeling using *ab initio* and Calphad (Calculation of Phase Diagrams) techniques. The  $\sigma$ - and  $P$ -phases, now among the most intensively studied intermetallics owing to their tendency to precipitate from stainless steels in the form of austenitic, ferritic or austenitic-ferritic phases, have given rise to a large amount of literature in which the pioneering work of Clara and David is often referenced. Their later work included a wide range of such other intermetallic phases as  $\delta$ -Mo-Ni,  $\mu$ -MnAl<sub>4</sub>,  $E$ -TiNiSi,  $M$ -NbNiAl and  $\nu$ -Mn<sub>81.5</sub>Si<sub>18.5</sub>.

Clara's breadth of interests is hinted at by her four studies published with other colleagues, together with a fifth as the sole author. The first, in 1959, was undertaken jointly with Barbara Low, a crystallographer then associated with Harvard Medical School. The second, in 1961, also with Barbara and one of her colleagues, had the bold objective of outlining the gross molecular structure of crystalline Type A insulin sulfate. Their analysis of the three-dimensional Patterson function revealed two independent insulin molecules in the asymmetric unit but gave no evidence of extensive parallel  $\alpha$ -helices, a result now well confirmed. The third, a contrasting small-molecule study in 1965 of (CH<sub>3</sub>)<sub>2</sub>SO in collaboration with Klass Eriks of Boston University and one of his students, was undertaken to resolve a controversy then current concerning the nature of the S—O bond. Some authors described it as semipolar, others as a double covalent bond. On correction for librational motion, Clara and colleagues determined  $d_{S-O} = 1.531(5)$  Å, significantly shorter than expected if it were semipolar, *i.e.* with both binding electrons originating at one atom. The fourth collaborative study, with Bill Pearson at the NRC in Ottawa, was undertaken in 1969 to form a coding system applicable to a wide range of layered, tetrahedrally close-packed structures forming  $\beta$ -tungsten,  $\sigma$ -,  $P$ - and related phases that subsequently enjoyed wide use. In 1983, Clara was the sole author of a paper concerned with a hypothetical tetrahedrally close-packed  $\sigma$ -phase structure proposed by Erwin Parthé and collaborators in their structural study of TiMnSi<sub>2</sub>; she was able to identify an earlier study of the Fe—Si—W system that clearly demonstrated the existence of such a 'pentagon- $\sigma$ ' structure with the composition FeSiW<sub>2</sub>.

Clara jointly published over two dozen papers in *Acta Cryst.* with David in the years that followed. One was an organic complex precursor to the anti-tumor agent verrucarol and related antibiotic substances, isolated from a soil fungus. Its structural determination provided a class project in a graduate course they ran jointly at Oregon State University following their move to Oregon. Their publications were not entirely confined to *Acta Cryst.*; they discussed the structure of the V—Ni—Si  $I$ -phase and the Mn—Co—Si  $S$ -phase in *Trans. Met. Soc.* in the sixties, also three-dimensional Euclidean space filling by irregular tetrahedra in *Phys. Rev. B* 20 years later.

In 1970 David accepted both the Chairmanship of the Chemistry Department at Oregon State University and the presidency of the American Crystallographic Association. Clara and David remained fully engaged in ACA and IUCr activities following their move, including attendance at all IUCr Congresses from the 4th (Montreal, 1957) to

the 13th (Hamburg, 1984). Clara, of course, anticipated an appointment in the OSU department similar to that she held at MIT, but a hurdle existed in the form of state regulations concerning nepotism. These regulations prohibited close family members from holding faculty positions at the same time, not only at the same university, but anywhere within the state system of higher education. These regulations had been enacted during the Great Depression but had mostly been ignored in later years; they could, however, be invoked at any time by an administrator who so wished. (Lise Hedberg, wife of one of the present authors, had encountered this problem after working several years in the OSU Chemistry Department). Responding to David's concern, the potential impediment to Clara's appointment was examined by the president of the university, Dr Robert MacVicar, who discovered that the law prohibiting joint family appointments contained the modifying phrase: '...except under exceptional circumstances'. President MacVicar thereupon announced that any husband and wife scientific team qualified as an exceptional circumstance and Clara's appointment, as well as Lise's reinstatement, went forward. There was a small caveat: in order to preserve the appearance of propriety, neither lady could be supervised by her husband. Instead it was determined that each husband would take responsibility for the scientific effort of the other's wife. This arrangement required that each husband assure the other that his wife was doing a good job. The process was certainly easy to carry out, but seems a bit comical in retrospect.

In the years following Clara's retirement, both she and David continued their joint research each day. She gave hers up after David's death in 1995, the last of her publications appearing about 10 years after she retired. However, she maintained her department contacts, joining a luncheon discussion group each Friday and participating in morning coffee-break sessions. She enjoyed both chamber and orchestral music and regularly spent several days in Ashland attending the renowned Oregon Shakespeare Festival theater twice yearly. Her declining health and dislike of night driving forced her later to terminate attendance at concerts, but she continued travelling to the festival each spring in the company of friends.

Erudite and cultured, Clara was also kind, gentle and characteristically reserved. She loved her family and was proud of her son Robert, Professor of 18th-Century British History and Co-Director, Old Bailey Online, Plebeian Lives and the Making of Modern London at the University of Sheffield in the UK. She was delighted that her grandson Roland is presently a third-generation Shoemaker undergraduate at Reed College. Clara Brink Shoemaker was a fine person in every respect, and her friends and colleagues will miss her greatly.

The biographical notes on Clara compiled by Mary F. Singleton, available at <http://osulibrary.oregonstate.edu/specialcollections/coll/shoemaker/singleton/page1.html>, are acknowledged with gratitude.

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