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EDITORIAL

From an electron micrograph to a postage stamp

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Abstract Soon following Dan Shechtman's discovery of quasicrystals, Ágnes Csanády and her associates started producing beautiful quasicrystals of flowerlike morphology. The image of one of their specimen appeared on the Israeli postage stamp honoring Shechtman's discovery, his Nobel Prize, and the International Year of Crystallography.

Keywords Dan Shechtman · Ágnes Csanády · Quasicrystals · Flowerlike morphology · Electron micrographs · Symmetry · Postage stamps

Dan Shechtman was conducting experiments with alloys in the spring of 1982 at the National Bureau of Standards (NBS, as it was then) in Washington, DC. Shechtman had developed a technique for studying metallic powders by transmission electron microscopy at the Technion—Israel Institute of Technology. At NBS, he collaborated with associates of the metallurgy group in producing and analyzing rapidly solidified aluminum-iron and other aluminum alloys, including aluminum-manganese alloys. Frank Biancaniello was Shechtman's enthusiastic colleague in preparing alloys of a great variety of composition. Of the aluminum-manganese alloys, the practically useful ones contained only a few percent of manganese. However, it seemed that alloys much beyond the practically useful manganese content might be also of interest to study. As they put an alloy with 25 percent manganese content into the electron microscope, Shechtman made a most unexpected observation. The electron diffraction diagram showed ten-fold symmetry. This happened on April 8, 1982, and it was for the first time that someone observed and recorded symmetry in the condensed state that classical crystallography deemed impossible in crystals.

Shechtman had a hard time getting his interpretation of his observation accepted by the crystallographic community and the broader scientific community. However, when he published his experiment in 1984 [1], an avalanche of studies and papers appeared, and many laboratories worldwide produced the new substance for which the name quasicrystals had been coined—short for quasiperiodic crystals. The story has been well documented (see, for example, [2–6]). From early on following Shechtman's discovery, I found that Ágnes Csanády and her colleagues produced the most beautiful quasicrystals at the development center of the Hungarian Aluminum Industry (Fig. 1).

Csanády and her group conducted extensive studies of the morphology of quasicrystals and the phase transformation of quasicrystals to crystals [7]. Some of the specimen selected for such investigation were quasicrystals of flowerlike morphology that Csanády and her colleagues started describing in 1987. They followed the phase transformation directly and observed that the nucleation of crystallization started on the surface of the icosahedral phase. As the new phase grew, the icosahedral phase kept shrinking. Here one has to be careful with semantics. At the time indeed they had to speak about phase transformation from the quasicrystal phase to the crystalline phase. Today, such a usage of terminology appears obsolete as the current

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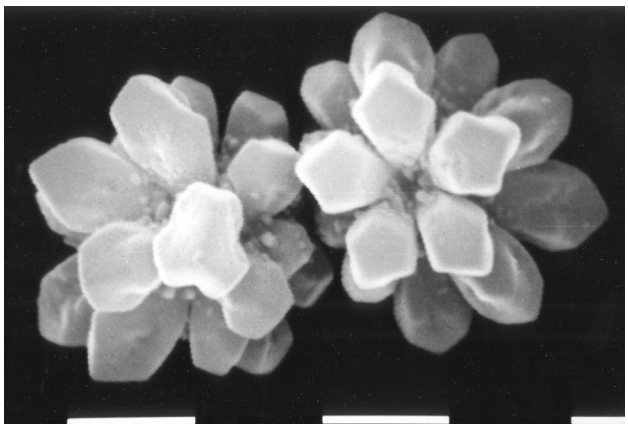

Fig. 1 Electron micrograph of flowerlike quasicrystals of a quenched aluminum-manganese alloy. The length of the full horizontal bar corresponds to 1μm (courtesy of Ágnes Csanády)

Fig. 2 Ágnes Csanády and Dan Shechtman in 1995 in Balatonfüred (photo by I. Hargittai)

definition of what a crystal is includes quasicrystals; then, this was not yet the case.

Above, I made reference to Csanády et al.'s paper in the periodical Symmetry [7]. This was a curious publication that did not survive its charter issue, but it was quite an issue. As I am mentioning this attempt for a uniquely interdisciplinary journal, Symmetry, it was exactly 25 years ago that its only issue appeared. It happened so that some of the communications in this issue were quite relevant to those interested in quasicrystals. I mention here a few only. Alan L. Mackay, major player in the quasicrystal story, wrote a thought-provoking essay, "Lucretius: Atoms and Opinion" [8]. Arthur Loeb and his co-authors discussed the icosahedron, pentagonal dodecahedron, and the rhombic triacontahedron [9]. Magnus J. Wenninger wrote about polyhedra and the golden number [10]. I single out a few additional contributions that were of a broader scope, from Erwin Chargaff [11], Herbert A. Hauptman [12], Jerome Karle [13], and Ernő Lendvai [14].

In May 1995, we organized an international school/conference on quasicrystals in the resort place at Lake Balaton, Balatonfüred, Hungary. There, in an unhurried atmosphere, we could learn, exchange ideas, and enjoy being part—at least as onlookers—of a fast emerging field. It was on this occasion when Ágnes Csanády could demonstrate personally her flowerlike quasicrystals to Dan Shechtman and everybody else (Fig. 2).

Shechtman discovered the quasicrystals on April 8, 1982. His report with co-authors appeared in November 1984 [1]. The Royal Swedish Academy of Sciences announced Shechtman's Nobel Prize in October 2011. The discovery was straightforward, but the scientific community, especially those deeply rooted in the teachings of classical crystallography, were slow in accepting it. By the time the International Year of Crystallography came about

Fig. 3 Israeli postage stamp (2013) honoring Dan Shechtman's discovery of quasicrystals and his Nobel Prize of 2011 as well as the International Year of Crystallography of 2014. The original image of the quasicrystals displayed on this postage stamp is that in Fig. 1

in 2014, the discovery of quasicrystals were among the stellar achievements of recent science.

When toward the end of 2013, the Israel Postal Company decided to issue a postage stamp to commemorate Dan Shechtman's Nobel Prize for the quasicrystal discovery and

to honor the International Year of Crystallography (2014) they associated Csanády's appealing flowerlike quasicrystals with Shechtman's electron diffraction pattern. The Israel Postal Company made an excellent decision to put quasicrystals on a postage stamp and they chose one of the most beautiful representatives of such substance for display. The result was a scientifically sound and aesthetically pleasing image (Fig. 3).

Csanády's quasicrystals and Shechtman's electron diffraction pattern were immortalized. Science has gained a tool for popularization in an unobtrusive and straightforward manner.

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