Invited Lecture

Atomic and Flashy Quasicrystals

L. Bindi

Department of Earth Sciences, University of Florence, Florence, Italy
luca.bindi@unifi.it

Quasicrystals, solids with rotational symmetries forbidden for crystals, are usually synthesized in the laboratory by mixing specific ratios of selected elemental components in the liquid and quenching under strictly controlled protocols. However, the discovery of natural quasicrystals in the Khatyrka meteorite [1,2] showed that these unusual phases could also form in high-velocity impact-induced shock events introducing an endeavour to search them in other materials subjected to transient *P*/*T* conditions.
In this talk, the Author will describe the occurrence of the first Si-based icosahedral quasicrystal in the material (trinitite) formed during the first atomic bomb test, i.e. the Trinity test [3]. Also, the first quasicrystal with dodecagonal symmetry found in a fulgurite, a material formed by lightning strikes, will be also described [4].
The *atomic* quasicrystal, $Si_{61}Cu_{30}Ca_7Fe_2$, was found in remnants of the first test explosion of a nuclear bomb, the Trinity test of 16 July 1945. The studied material formed in the fusion of surrounding sand, the test tower, and copper transmission lines into a glassy material known as “trinitite”. It represents the oldest extant anthropogenic quasicrystal currently known, with the distinctive property that its precise time of creation is indelibly etched in history.
The *flashy* quasicrystal $Mn_{72.3}Si_{15.6}Cr_{9.7}Al_{1.8}Ni_{0.6}$ -- composed of a periodic stacking of atomic planes with quasiperiodic translational order and 12-fold symmetry along the two directions perpendicular to the planes -- accidentally formed by an electrical discharge event in an aeolian dune in the Sand Hills near Hyannis, Nebraska, United States. The quasicrystal was found in a fulgurite consisting predominantly of fused and melted sand along with traces of melted conductor metal from a nearby downed power line. The fulgurite may have been created by a lightning strike that combined sand with material from downed power line or from electrical discharges from the downed power line alone.
The discoveries of *atomic* and *flashy* quasicrystals could lead to new techniques for quasicrystal synthesis through controlled electrical discharges in the lab. This could enable researchers to engineer exotic new properties and may even help them to better identify places where natural quasicrystals can be found, both on Earth and in space.

[1] Bindi, L., Steinhardt, P.J., Yao, N., Lu, P. (2009). *Science* **324**, 1306.

[2] Bindi, L., Eiler, J.M., Guan, Y., Hollister, L.S., MacPherson, G.J., Steinhardt, P.J., Yao, N. (2012). *Proc. Natl. Acad. Sci. USA* **109**, 1396.

[3] Bindi, L., Kolb, W., Eby, G.N., Asimow, P.D., Wallace, T.C., Steinhardt P.J. (2021). *Proc. Natl. Acad. Sci. USA* **118**, e2101350118.

[4] Bindi, L., Pasek, M.A., Ma, C., Hu, J., Cheng, G., Yao, N., Asimow, P.D., Steinhardt, P.J. (2023). *Proc. Natl. Acad. Sci. USA* **120**, e2215484119.