Baltic amber and imitations under the electron microscope

Amber Microworlds

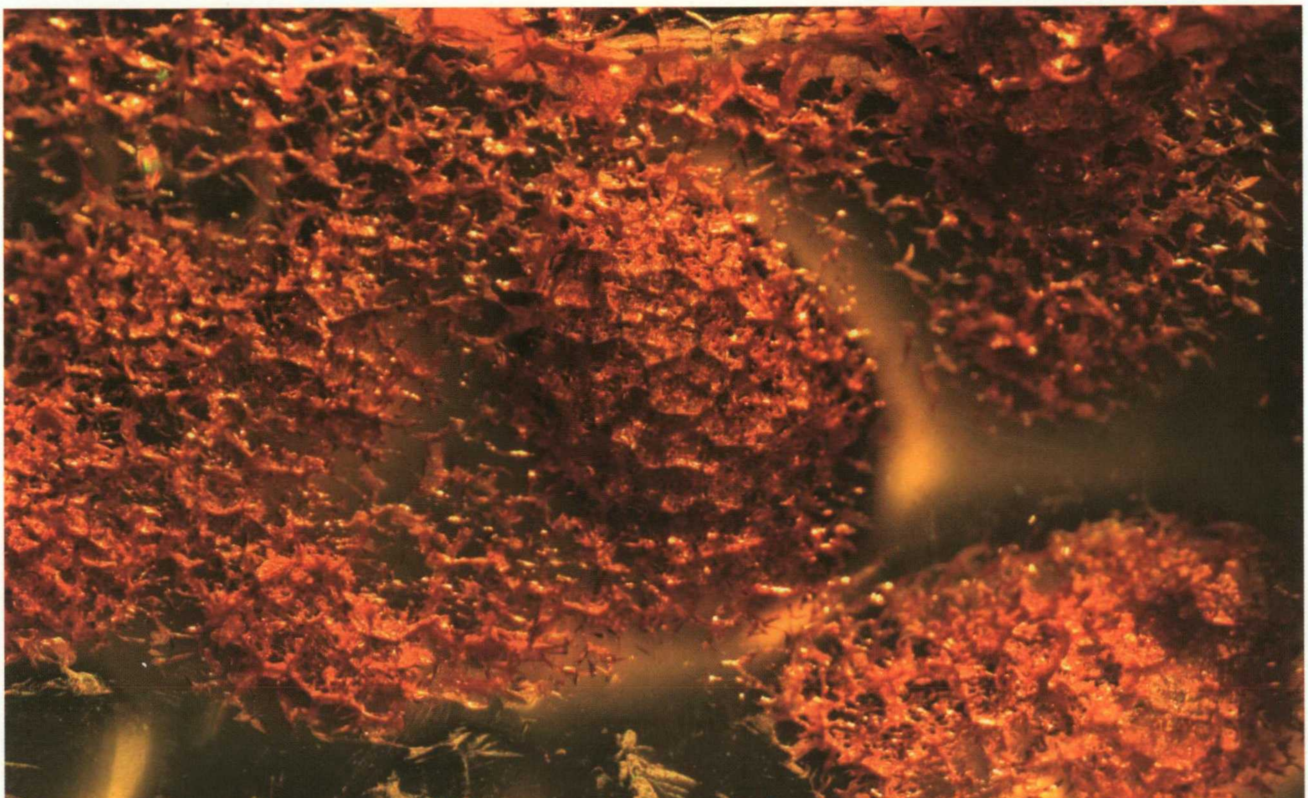
BARBARA KOSMOWSKA-CERANOWICZ
Museum of the Earth, Warsaw
Polish Academy of Sciences
koscer@obywatel.pl

Like all precious gemstones, Baltic amber (more precisely termed "succinite") is struggling against an ever-expanding plague of better and better imitations. Electron microscopy, used as a method for distinguishing between amber and closely similar substances, is at the same time unveiling as-yet unknown secrets of these golden jewels

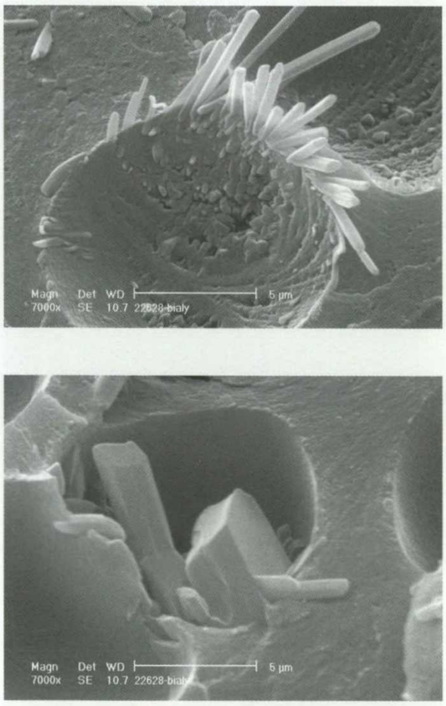
Poland has become one of the leading producers of amber jewelry in the past quarter century, now processing some 200 tons annually. Over the past 12 years the city of Gdańsk has become a major processing center of Baltic amber, a commodity associated with our country for centuries, and has been dubbed the amber capital of the world. Through close contacts with the amber-working community, scientists from the Museum of the Earth have had the opportunity to obtain interesting amber specimens for their research - which on the one hand is broadening our understanding of the substance itself, and on the other helping identify traits to differentiate Baltic amber from other fossil resins and imitations.

Certain features of amber that have long been known, especially its 3-8% content of succinic acid,

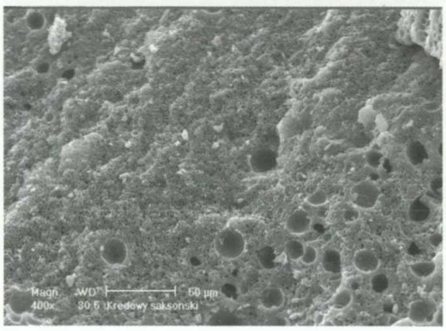
Janusz Kuprijanowicz



Baltic amber of the sugar variety from the Museum's collection. The name comes from the characteristic network of tiny cracks which macroscopically resemble a sugar cube with tightly packed, glistening crystals were used as hallmarks to facilitate identification as early as in the 19th century. Nowadays these time-honored techniques have been replaced by definitive methods using infrared absorption spectrometry. Better methods are necessitated by the fact that about 120 other fossil resins exist in the world, particularly coming from the sedimentary rocks of the Cretaceous and Paleogene. Few of them can rival succinite, but some are indeed similar enough to imitate Baltic amber. Although spectroscope methods are widely used for preliminary investigation, additional means must be sought to distinguish other resins from natural succinite. Due to the deficiency of the raw material, various amber-processing techniques are now being employed with increasing frequency, using autoclaves and presses; materials like copal imported from Colombia can be hardened in order to make them



Crystals of various habits inside gas bubbles in amber of the chalk variety from Saxony. The lack of heavier elements indicates that they formed from the compounds of the amber itself



In white transparent amber the gas bubbles take a large percentage of space. Several generations of bubbles are visible

more akin to succinite. Such techniques involve high temperatures, high pressures, and the mixing of amber with not-completely-fossilized resins, or even artificial ones. Such efforts result in excellent imitations, which are unfortunately frequently sold as natural amber.

The Museum of the Earth's project to harness scanning electron microscopy in amber research, undertaken in cooperation with the PAN Institute of Paleobiology in Warsaw, aims to gather materials to facilitate the further fundamental study of the microstructures present in different varietes of natural amber, and to investigate whether electron microscopy can serve as a method for conclusively identifying amber gemstones.

Solid foam

Optical microscope investigations noted the foamy internal structure of amber as early as in the mid-19th century, and even identified the diameters of the gas bubbles present in its different varietes. Once electron microscopy was developed, it too was harnessed for amber research.

Our study has looked at unpolished, freshly fractured samples of amber from the Baltic Sea countries, from Ukraine, and from Saxony-Anhalt in Germany. These three regions evidence the same kind of fossil resin, succinite. Its chief variations were studied: opaque white, opaque yellow, and transparent amber, and it was hoped that natural porousness would hold the key to identifying hallmark differences. Production workshops are still trying, by the trial-and-error method, to obtain porous structures in their materials that are similar to naturally-occurring ones.

The bubbles in the structure of the white amber are highly dense. The gas bubbles are spherical, with the exception of Saxon amber, where they oblong shape evidences a natural process of the bubbles' closing off towards the outer edges of the lump. Gas bubbles of several generations, of various size, are almost always observed in the porous structure of amber (which actually is a solid foam). Their diameters range from 313 nm up to 20 µm.

Similar porous structure has not been found in samples of opaque yellow amber. Sometimes a certain concentration of bubbles occurs along the edge of the sample, while a solid structure is found closer to the center. This suggests a hypothesis that the opaqueness of certain varieties of amber (especially the yellow sort) is not caused exclusively by their porous microstructure, as previously thought.

The transparent amber studied, in turn, showed a solid structure only sometimes containing larger-sized bubbles visible to the naked eye, and also evidenced a clear-cut stratified structure, with the individual resin layers usually of a small, even minuscule thickness.

Michał Kazubski

Baltic amber of the opaque white variety from the Museum's collection. Opaque white and opaque chalk varietes have a structure of "solid foam" in which a large percentage of space is occupied by gas bubbles, typically of several generations and sizes. Inside these bubbles, various shaped microcrystals have been uncovered during SEM (scanning electron microscopy) observations

Hidden Crystals

Aside from studying the microstructure of amber, the research initiated by the Museum of the Earth has - for the first time - identified the presence of a crystalline phase in amber, using X-ray techniques.

Current research has likewise observed microscopic crystals in several specimens of opaque white amber, some from the Bitterfeld deposit in Germany. They occur on the insides of gas bubbles, much like the quartz lining found inside oval geodes. These discovered crystals show different habits (crystal appearances). One of the largest bubbles hosts crystals of a tabular habit, while the smaller bubbles have only individual crystals of a prismatic habit or entire sets of bent fibrous crystals. No heavier elements were found within these crystals, a fact that might indicate that they formed from the compounds comprising the amber itself. It will be up to further research to identify what mineral these micro-crystal inclusions are formed by.

The weathering of both opaque white and transparent amber can produce a very attractive variety called "sugar amber," which is reminiscent of a glistening sugar cube. Investigations using a scanning microscope have shown that the impressive internal reflections of this type are the result of microscopic cracks appearing along so-called conchoidal fractures, i.e. uneven, concentric, undulated, spherical surfaces, similar to mussel shells. Such cracks can form in amber fragments of solid as well as porous structure.

While we have not yet unlocked all of amber's secrets, the facts we have so far uncovered make the mineral not only an attractive decorative stone that has fascinated man since the dawn of history, but also an intriguing subject of scientific research. ■

Further reading:

Foks J., Janik H., Kucharska M., Kwiatkowski A. (1980). Microstructure study of Baltic ambers of various levels of transparency [in Polish]. *Przegląd Geologiczny*, t. 28 nr 11, 621-624.

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