Inland Amber

The main variety of amber occurring in Poland is succinite, colloquially known as "Baltic amber"

BE&W

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Dr. Jacek Kasiński is a chief technical research specialist at the Polish Geological Institute, where he studies the stratigraphy of the Paleogene and Neogene and the geology of lignite deposits. For many years he headed the sections for lignite geology and geology of mineral deposits. In 1994-1997 he was involved in a project of geological work identifying the prospects for amber deposits occurring in Eocene formations in the Lublin region. He works on the Institute's Energy Security Program.

"Baltic amber," the commonly-used name for succinate, is somewhat misleading – as this variety of amber in fact has no inherent connection with the Baltic sea. Poland's largest deposits of such amber actually occur in the country's southeast, in the area north of the town of Lublin. What will it take for those deposits to be harnessed?

Amber is formed through the diagenesis of ancient resin – a substance secreted by certain polyphyletic groups of plants, particularly intensively as a reaction to stress caused by external impact. The most important diagenesis processes involve polymerization, giving rise to macromolecules (polymers, or more often copolymers). The resulting range of products includes subfossil resins (copal) and fossil resins (amber). The more polymerized members on this scale exhibit significantly greater mechanical resistance than natural resins, and significantly lower chemical reactivity. These characteristics enable amber to persist in sediment deposits for very long times.

Long route

Baltic amber is the product of resin production in forests that grew on the eastern epicontinental portion of the North Sea basin back in the Paleogene. In the 19th century, Baltic amber was thought to derive from the resin of a hypothetical representative of the pine genus, described as the "amberiferous pine" (*Pinus succinifera*), but more recent paleobotanical research and chemical and spectroscopic analysis of both amber and modern resins (as a comparative point of reference) have indicated that Baltic amber mainly comes from the resin of several Paleogene species of gymnosperm plants. The modern-day plants thought most likely to be related to those ancient amber-bearing plants are in the groups Sciadopitaceae (*Sciadopitys verticillata*), Pinaceae (*Pinus lambertiana*), Taxodiaceae (*Pseudolarix vehri*) and Araucariaceae (*Agathis australis*).

The largest marine transgression of the Paleogene period took place during the middle Eocene epoch, reaching its maximum in the late Eocene. The developing basin of northwestern Europe then became connected with the boreal province of the Donetsk-Caspian basin via the eastern portion of today's Baltic, and to the Mediterranean basin of the Alpine-Carpathian forefield via the Moravian Gate. Sea waters entered today's Baltic basin in the late Eocene and early Oligocene.

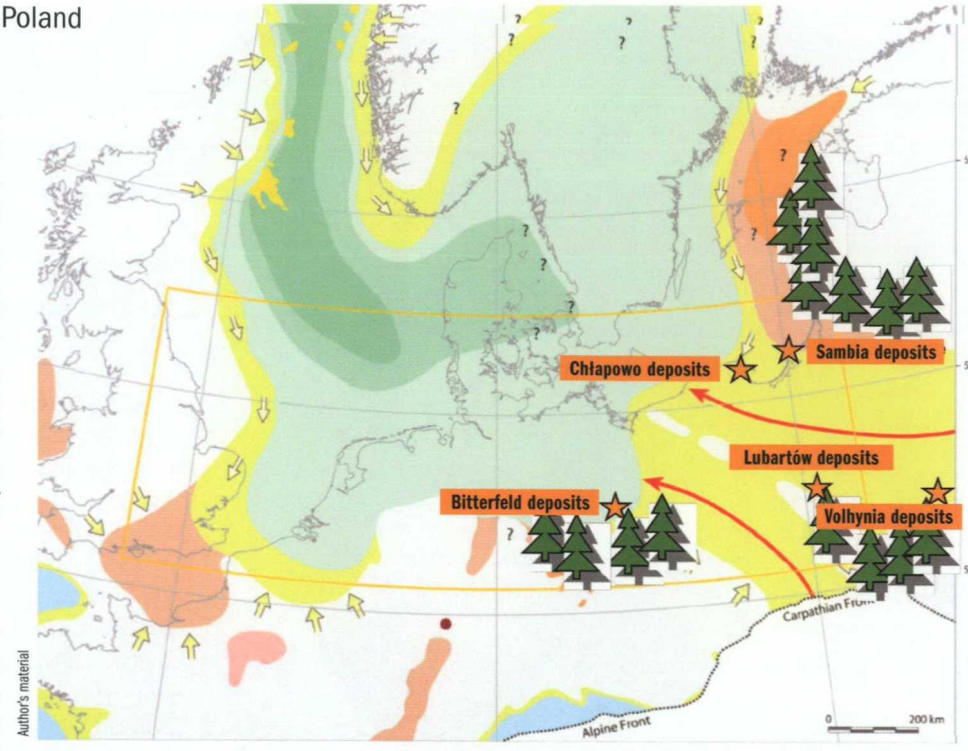
Shallow-water, coastal-marine, and lagoon-delta *facies* (bodies of rock) developed in certain areas of the sea basin: to the north, in today's Gdańsk Gulf together with coasts on the north, and to the south, in the northern part of the Lublin region and Volhynia, which were adjacent to the Baltic Shield and the Metacarpathian Swell, and also in Lower Lusatia and Saxony, located to the north of the Lusatian Massif. Resin was transported by rivers draining the land and, in view of its low density, probably also carried by surface floods into the sea basin. There, interacting with the salt water caused its diagenesis, leading to the creation of amber. The once commonly-held view that amber was deposited exclusively in the river deltas of large rivers can no longer be defended. On the contrary, all amber deposits show signs pointing to a marine environment (marine fauna, dinocysts, glauconite). The appearance of primary accumulations of amber-bearing deposits is associated with regressive marine facies, and the geometry of lithosomes suggests that amber deposition was related to the periodic slowing of regression. In low-energy regres-

sive facies, amber occurs mainly among silts and fine sands. When environmental energy increased (e.g. as a result of another transgression), it was usually eroded from its initial deposits and redeposited in younger sediment.

The age of the resin secretion processes themselves is not known exactly. We only know that the oldest deposits of Baltic amber occur in marine deposits of the middle and upper Eocene. Baltic amber deposits are distributed quite evenly in the littoral zone along the eastern coast of the Eocene sea.

Steps to extraction

The richest deposits of Baltic amber, accounting for around 90%, occur in Eocene formations in the western portion of the Sambia Peninsula (in Russia's Kaliningrad district). The same Baltic amber is found in Volhynia (in lower Oligocene formations) and in the region of Bitterfeld (in Miocene sediments), and also, in numerous but small deposits, in sediments of the Pleistocene and Holocene on the Polish Lowlands. Deposits regarded as primary occur also in Poland - on the Kashubian coast and in the north of the Lublin region.



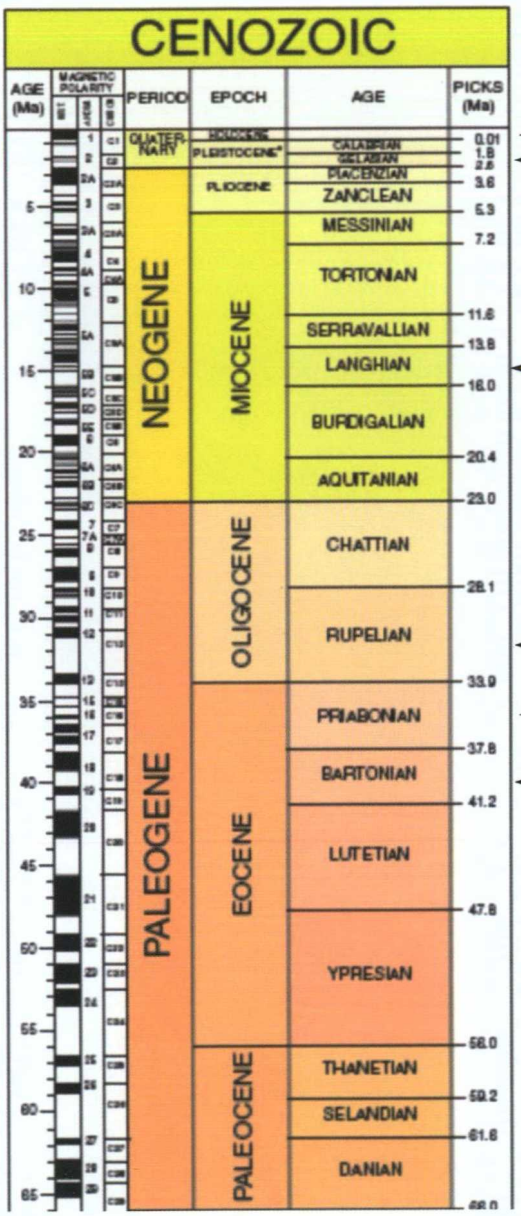
Sea waters entered the sedimentary basin in the late Eocene and early Oligocene. Tree resin was transported by rivers to the sea basin. There, interacting with the salt water caused the resin to undergo diagenesis, leading to the formation of amber.

The deposits of the Kashubian coast represent a direct continuation of the Sambia deposits. The substratum of amber-associated formations contains Pomeranian Formation deposits, in the form of non-calcareous siltstone with glauconite. The occurrence of amber is related here with the Połczyn Formation - a Lower Mosina Formation taking the form of grey-green sandy silts and silty sands with glauconite and muscovite and individual phosphates. The sediments include fragments of mollusk shells and numerous traces of benthonic organisms (bioturbations). The Połczyn Formation is the lithostratigraphic counterpart of the "blue earth" occurring on the Sambia Peninsula, and its age is identified as the uppermost Eocene (Priabonian). The thickness of the Połczyn formation on the Kashubian coast is 3-13m, but in the western portions the amber-associated formations were scattered more than 100 m along the longitudinal fault running under the floor of the Gdańsk Gulf and are now at a depth of 118-128 meters below soil surface. Even though the average amber content in the Chłapowo I borehole is high, even as high as 996 g/m^3, and the total resources there are estimated at 591,000 Mg, the depth of the deposit precludes its profitable mining. The presence of numerous nature sites under protection (Natura 2000 areas, the Coastal Landscape Park, the protected eroded Baltic cliff coasts) in the area is also a significant factor.

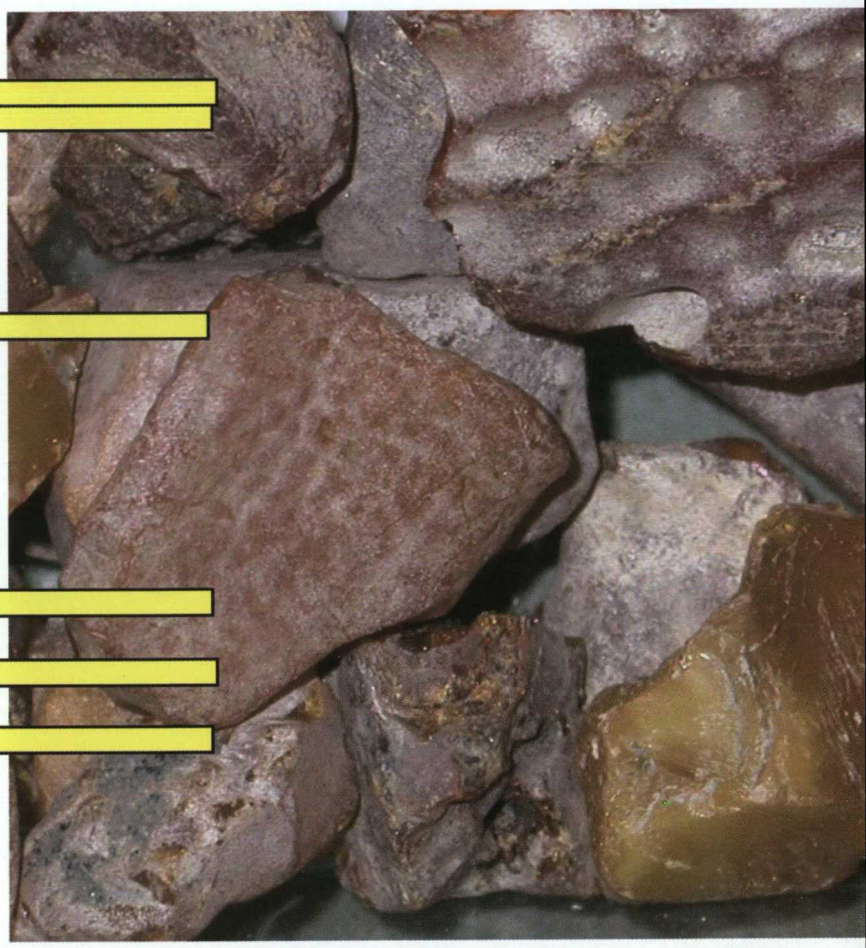
The deposits in the northern Lublin region, on the other hand, are more promising, particularly due to their primary nature, nested structure of occurrence, and accessibility. Amber-bearing deposits belonging to the Upper Bartonian and Priabonian here lie directly on the Maastrichtian deposits, taking the form of marls, limestones, and decalcified siliceous rocks (gaizes). Classified among the Siemień formations, the amber-bearing deposits are represented by quartz-glauconite sands with gravel, phosphates, and amber, as well as grey-green sandy silts with fauna.

The documented amber content in the Lublin deposits are nearly 1100 Mg. Because the amber-bearing association occurs there at an average depth of 15-20 m below ground, the hydraulic-washout method cannot be used. Rather, amber mining here will likely have to employ "classical" open-pit mining methods (either "dry," after draining the excavation, or from under water, without

scale of polymerization:		
modern resin	**subfossil resin**	**fossil resin**
RESIN	COPAL	AMBER
arabic gum	kauri gum	rumenite
dammar gum	Benguela copal	Baltic amber
myrrh	Columbian copal	burmite
sandarac	Zanzibar copal	middletonite
recent	Quaternary	Paleogene - Carboniferous



The recent distribution of amber is the result of multiple erosions of amber-bearing sediments, whereby the amber was usually washed out of primary deposits and redeposited in younger sediments



Author's material

Baltic amber is currently harnessed in Poland exclusively from small redeposited accumulations occurring very shallowly in Quaternary deposits in the Vistula delta and on the Baltic coastline. There, haphazardly mixed with the remains of wood and macrofauna, amber became deposited there by the surf zone in the form of several narrow bands parallel to the ancient coastline. We are familiar with more than a dozen such deposits, but the resources of each of them do not exceed 2 Mg. The shallow depth of deposition enables the hydraulic washout method to be used to recover the amber, which involves pumping water into the deposit at a pressure that washes out the amber-bearing sediments (mainly sand) and draws the sand together with amber pebbles to the surface.

drainage) or the hydraulic-mechanical method, which involves washing out amber-bearing sediments using water supplied by a mining head lowered down into successive boreholes. Even though such mining requires extensive surface transformations, it is possible here in view of the lack of developed or environmentally protected areas. ■

Further reading:

Kasiński J.R., Tołkanowicz E. (1999). Amber in the northern Lublin Region – origin and occurrence. (In:) B. Kosmowska-Ceranowicz, H. Paner (eds.). *Investigations into amber, 41-51*, Gdańsk: Gdańsk Arch. Museum.

Kosmowska-Ceranowicz B., Kociszewska-Musiał G., Musiał T., Muller C. (1990). *Bursztynonośne osady trzeciorzędu okolic Parczewa* [Amber-Bearing Tertiary Sediments near Parczew]. Prace Muzeum Ziemi, 41, Warsaw.

Kramarska R., Kasiński J.R., Sivkov V. (2008). Bursztyn paleogeński in situ w Polsce i krajach ościennych – geologia, eksploatacja, perspektywy [Paleogene Amber in situ in Poland and surrounding countries – geology, exploitation, perspectives]. *Górn. Odkrywkowe 50*: 2/3, 97-110, Wrocław.

Piwocki M., Olkowicz-Paprocka M.I. (1987). Litostratygrafia paleogenu, perspektywy i metodyka poszukiwań bursztynu w północnej Polsce [Lithostratigraphy of the Paleogene, Forecasts and Methods of Amber Exploration in Northern Poland]. *Biul. Inst. Geol., 356*, 7-28, Warsaw.