ACTA ACADEMIAE ARTIUM VILNENSIS / 22 2001

OUTLINE ON GEOLOGY OF AMBER-BEARING DEPOSITS IN THE SAMBIAN PENINSULA

Algimantas Grigelis
Lithuanian Institute of Geology

Amber - this unique mineral is a natural organic compound known in mineralogy as succinite. History of amber formation, extraction and use is very interesting for a geologist or mineralogist, zoologist or botanist, as well as for archaeologist and artist. What does our modern knowledge tells about it?

Formation of the Sambian amber sites covers the beginning of Cenozoic, the Paleogene period that lasted about 41.5 million years (Ma), i.e. from 65 to 23.5 MA before present. At the end of preceding Cretaceous period (65 Ma BP) the area of present Lithuania and South East Baltic Sea rose and turned into land. At the start of Paleogene the basin sunk again, marine regime prevailed and lasted, with several intervals, by the end of the Paleogene. In the north this basin seems to have been stretched up to the recent shores of Skåne (South Sweden). In Miocene the marine basin retreated finally and the south-western part of the Baltic area turned into a closed lake plain.

The geochronological data show that in mid-Paleogene, at the end of Eocene (53-33.7 Ma BP), under the humid (moist and warm) climate of North Europe, amber forests were growing in the South and Central Scandinavian hills. The amber forest was mainly represented by an amber-rich pine (Pinus succinifera, extinct later) that had produced resin in large quantities. In Late Eocene the primary deposits of this resin were formed in the sites of, later the resin underwent a fossilisation and turned into an amber. The deposits did not survived due to river activities, and amber was being brought to other sites. The configuration of the Baltic-Scandinavian marine basin and development of thereof determined the result that amber as a mineral was redeposited in the river delta in the place of the present-day Sambian Peninsula, in Priabonian (37-33.7 Ma) deposits of Prussian Formation. Hence, in Sambia, the amber deposit the largest in the world has been formed in Palvininkai (Yantarnoye).

What are the most typical geological features of the Sambian amber deposit?

The geological conditions that had existed in Lithuania and East Prussia during Paleogene determined the variety of sedimentary rocks consisting of various facies, including terrigenous deposits, calcareous and silicified deposits are of marine origin here, while those of Eocene and Miocene are of continental (lake) origin. Marine deposits contain various faunal remains, whereas continental ones are rich in microflora, which has been used for stratigraphy of the period.

Amber deposit in the Sambian Peninsula is formed during Late Eocene. Amber geology and palaeogeography is rather well studied. The first works were carried by the scholars of end-19th and beginning of 20th centuries, including geological (E.G.Zaddach, A.Jentzsch, A.Tornquist, F.Kaunhoven & O.Linstov), palaeontological (K.Mayer, F.Noetling & A.Koenen), and chemical-mineralogical (O.Helm, P.Dhams & R.Klebs) investigations. Numerous works were published on faunal amber inclusions.

Amber researches in mid-20th century were described by Lithuanian scientists P.Matulionis, P.Šivickis,

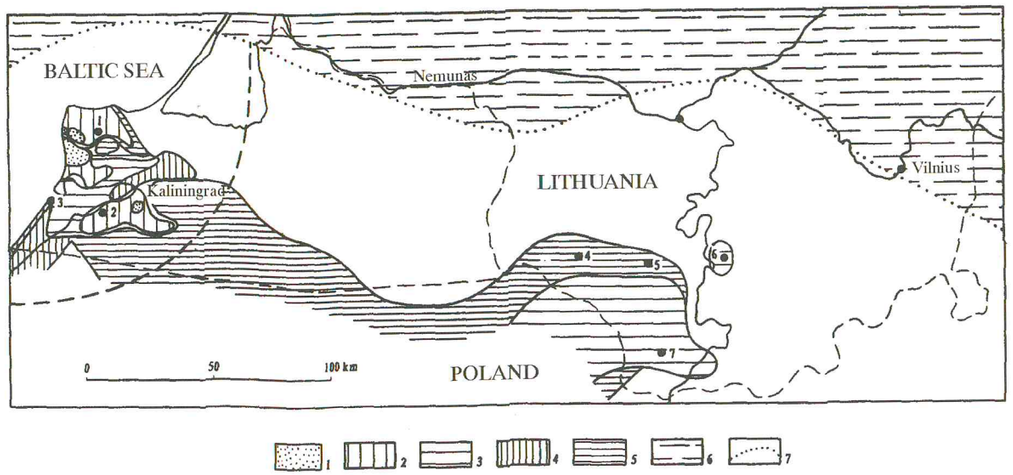


Fig. 1. Distribution of Paleogene rocks: 1 – Palvė Formation; 2 – Prūsai Formation; 3 – Alkas Formation; 4 – Sambija Formation; 5 – Liubavas Formation; 6 – denudational area; 7 – supposed northern border of Paleogene basin. Boreholes and their numbers: 1 – Markėnai -49; 2 – Ludwigsort -55; 3 – Baltic Spit -23; 4 – Kalvarija -2; 5 – Simnas-3; 6 – Jurkionys -51; 7 – Veisiejai -4.

M.Kaveckis, J.Kaškelis, J.Bubnys. In the second half of 20th century the amber strata geology was studied in detail by V.Baltakis and V.Katinas, and their stratigraphy was dealt with by A.Grigelis (Baltakis 1966, 1967; Katinas 1966, 1971; Grigelis 1971, 1977, 1996). The most exhaustive data on Baltic amber are presented in the treatise by Vl.Katinas (1983) and in a monograph "Geology of Lithuania" (1994). A book "Yantar" by S.Savkevich (1970) contains also many useful data.

Palvininkai (Yantarnoye) Amber Deposit

At the start of the period Paleogene basin deposits were widely distributed in the whole Baltic area. The basin was stretching farther southwards in Polish area (Fig. 1). Later, since the basin was regressing, its area was gradually decreasing. Therefore Late Eocene and Early Oligocene deposits are met only in Kaliningrad environs and Sambian Peninsula.

As we can see in the stratigraphic scheme, the Paleogene section is full composed of clayey and sandy deposits (Fig. 2). The age of the Paleogene deposits is based on fossils, whereas the stratigraphic division is done also according to deposit lithology. Among fossil remnants the Protozoan representatives, foraminifers, are most often detected – they have a calcareous shell and are well-preserved as fossils. According to the characteristic features, the section is divided into lithostratigraphic subdivisions – formations, beds, and members. They have their specific names. These are local stratigraphic units.

The amber rich beds are attributed to the Prūsai Formation of the Priabonian Stage. This is the well-known so-called Blue Earth (blaue Erde). The names of the beds are given by amber diggers at the end of 19th century. Facies of Prūsai Formation (composition of deposits) are greatly varying. The Blue Earth makes only a part of the Formation. The most comprehensive description of the section is given by V.Baltakis (1966). Going from the older beds upwards the sequence is as follows below:

1.Barren Earth. Glauconitic-quartzite sand with clay lumps and phosphorite nodules, up to 8-m thick.

2.Blue Earth. Brownish-green sandy aleurite with amber pieces, up to 10-m thick.

3.Shore- and Quick-sand. Oblique bedded glauconitic-quartzite sand cemented by iron hydroxides, up to 28-m thick.

4.Grey Wall. Glauconitic-quartzite sand with clay and aleurite interbeddings, up to 6-m thick.

Oblique lamination, transition of beds from one to another, both in vertical and lateral directions, indicate their formation took place in the underwater part of the delta (Fig. 3).

The palaeogeographic reconstructions show that at the end of Late Eocene the Priabonian basin, where

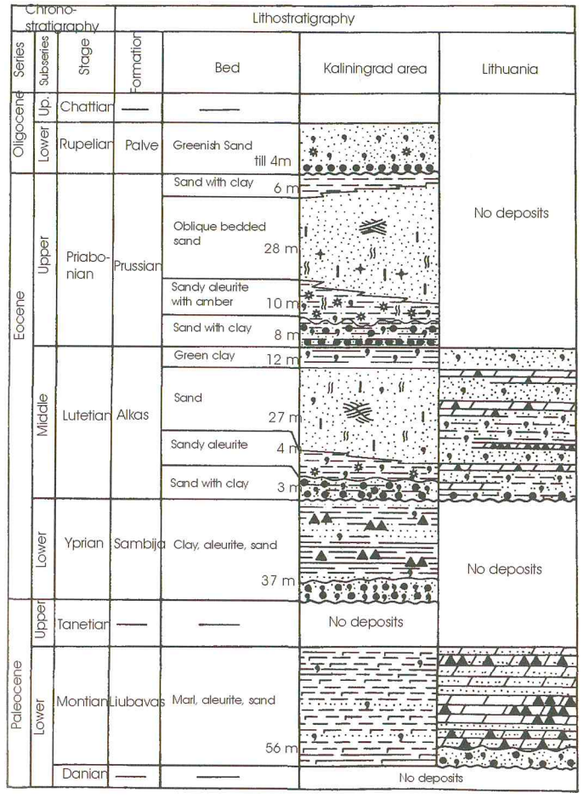
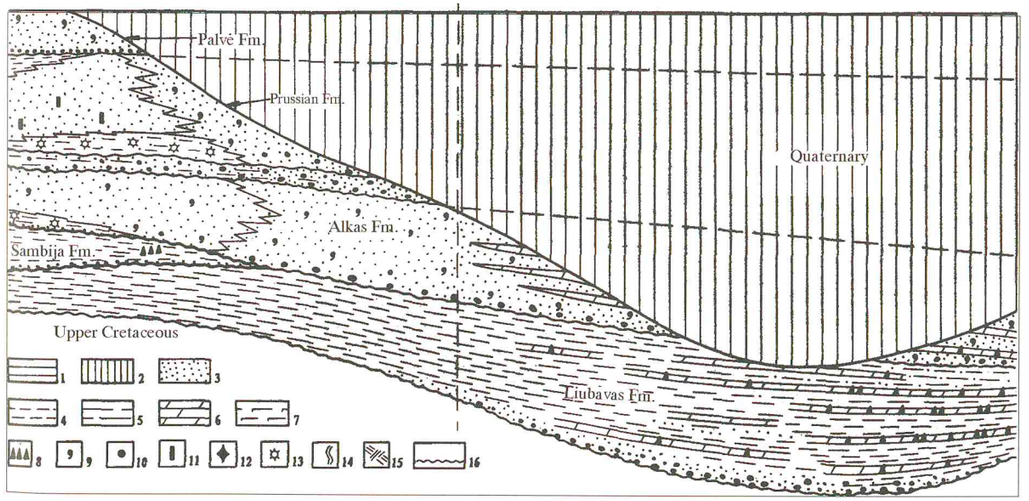


Fig. 2. Paleogene stratigraphic scheme. Explanation see in the text.

Fig. 3. Paleogene sedimentation scheme: 1 – land conditions; 2 – deposits eroded by Quaternary glaciers; 3 – sand; 4 – silt; 5 – clay; 6 – marl; 7 – calcification; 8 – silicification; 9 – glauconite; 10 – phosphorite nodules; 11 – siderite; 12 – iron hydroxides; 13 – amber; 14 – patches of earth-worms; 15 – oblique lamination; 16 – flooding surfaces (break of sedimentation).



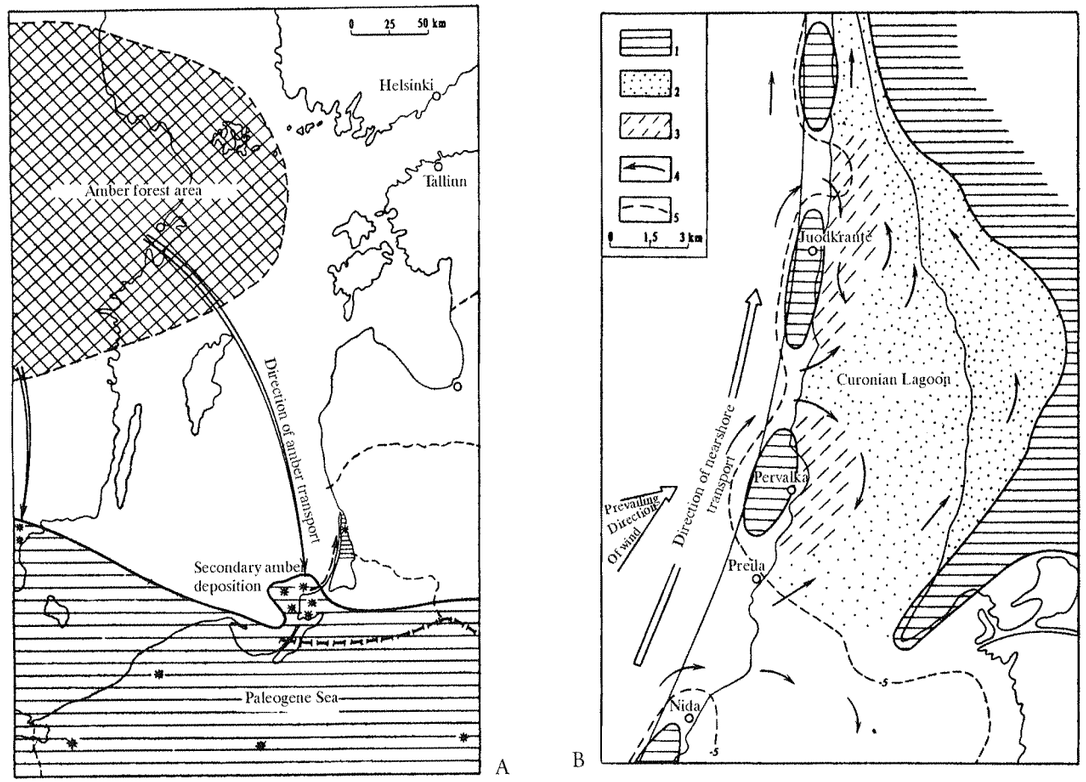


Fig. 4. Palaeogeographic environment amber deposits were formed: A – during Paleogene in the Sambian Peninsula, B – during Litorina time (Holocene) in the Lagoon of Kuršių Marios (Curonian Lagoon). 1 – land area; 2 – sand deposition; 3 – silt deposition; 4 – prevailing direction of currents; 5 – depth of lagoon (-5 m isobath).

Prūsai Formation sediments were settling, gradually started to become shallower. At that time the amber deposits ended their formation, since amber forests began deteriorating due to climate growing warmer in Eocene. Rivers running from Scandinavian slopes washed the placers of amber formed in the forest soil and spread the amber throughout the basin, especially at its southern margin. The most favourable conditions for accumulation of amber (we know the amber is a bit lighter than water) were in a deep quiet bay areas (avant-delta) (Fig. 4). With the Eocene ending the marine basin retreated from the Baltic area south-westwards.

The extractable resources of amber are known in a rather wide area on the western coast of the Sambian Peninsula (about 700 km2). The oldest Palvininkai (Palmnicken) deposit started to be exploited in mid-19th century by mining to the depths of Blue Earth, later stretts were being dug out in the amber-rich bed. After the start the Sambian amber mine used to produce up to 400 tonnes of amber per year. However geological conditions for mining were complicated, hence, in 1922 the underground mining of amber ceased. In 1912, north of Palvininkai, an amber pit (the olden one) had been opened; it used to be operated by 1972 with intervals.

After the World War II the mining in the olden pit resumed. Amber was necessary for industry, medicine (e.g., amber acid is used in production of high-temperature-resistant varnish and enamels). Palvininkai was renamed into Yantarnoye. Amber bed in the Yantarnoye deposit is 7-8-m thick, with the amount of amber dug out ranging from 0.5 to 2.5 kg from a cubic metre of the rocks. The Blue Earth occurs at 7 metres below the sea level, it is covered by 35-m thick deposits. Powerful

Fig. 5. Exploitation of amber-rich earth in Palvininkai (Yantarnoye) pit, in 1960. Photo by A.Grigelis

machines used to remove the cover down to the Blue Earth and the waste ground was disposed into the sea. The pit was being uncovered in three steps. The Blue Earth used to be excavated by clamshell excavator, but later the monitor was applied to wash the amber-rich earth with water to form a pulp mass that was brought to the dressing machinery. In the 1960s Yantarnoye pit reached high yields, but the exploitation was performed in an disorderly way (Fig. 5).

As the amber extraction in Yantarnoye pit was approaching its end, in 1952-1955 a new area of amber-rich beds on the sea coast near Yantarnoye was prospected and named as Primorskoye. This deposit has Blue Earth occurring in two zones: on the Beach at 8-10 m depths, and in a New Zone down to 40-60 metres. Exploitation conditions are better in the Beach Zone, since the cover is rather thin. The resources determined (prospected) in 1978 made up over 128 thousand tonnes, in 1977 about 700 tonnes of amber have been dug out, with amber content making up 2.2 kg/m3. Amber-rich beds are stretching towards the underwater slope, where in a 1.5-2-km long belt they are exposed on the sea bottom. The beds are eroded by waves, especially during storm periods. The amber washed out is transported with a nearshore drift to the Lithuanian shores.

Amber resources in the whole amber-rich area of the Sambian Peninsula reach several hundred thousand tonnes and make up over 90 percent of the world resources of amber.

In Lithuania amber is also found in the northern part of the Kuršių Marios (Curonian) Lagoon. The amber was brought and settled here in Holocene, when in the time of Litorina Sea the islands of Kuršių Nerija (Curonian Spit) were being formed. The amber was dug in Juodkrantė in the so-called Gintaras (Amber) Bay. From 1860 to 1899 (by Stantien & Becker Company) up to 60-80 tonnes of amber were dug out per year. Later there were also several attempts to prospect and dug amber in the Lagoon, but the attempts were not successful, the game was not worth a candle. Nevertheless, this issue waits for a geologist's word and future decision.

References

Baltakis, V., 1966. Paleogene und Neogene Sedimenformationen und lithologische Komplexe im Südbaltikum // - Vilnius: Mintis. - P. 277-323.

Grigelis, A., 1996. Lithostratigraphic subdivision of the Cretaceous and Paleogene in Lithuanian // Geologija, Nr. 20, 45-55.

Grigelis, A., Baltakis, V., Katinas, V., 1971. Stratigraphy of the Paleogene deposits of the Baltic area // Proceedings of Academy of Sciences of the USSR. Geological Series, No. 3, 107-116.

Grigelis, A., Burlak, A., Zosimovich, V. et al., 1988. New data on the stratigraphy and palaeogeography of the Paleogene deposits of the western part of European USSR // Sovetskaya Geologiya, No. 12, 41-54.

Grigelis, A. & Kadūnas, V. (Compilers), 1994. Lietuvos geologija = Geology of Lithuania. - Vilnius: Science & Encyclopaedia. - 447 p.

Kaplan, A., Grigelis, A. et al., 1977. Paleogene stratigraphy and correlation of the South-West Baltic area // Sovetskaya Geologiya, Nr.4, 30-43.

Katinas, V., 1983. Baltijos gintaras /Baltic Amber/. - Vilnius: Mokslas. 111 p.

Savkevič, S.S., 1970. Jantar /Amber/. – Leningrad: Nedra. 192 p.

ACTA ACADEMIAE ARTIUM VILNENSIS / 22 2001

THE STUDY OF AMBER PIECES WITH SEVERAL INCLUSIONS INSIDE

Laima Vaičiulytė

PALANGA AMBER MUSEUM (LITHUANIA)

The fauna, flora and ecological conditions of the ancient Baltic amber forest have been the object of study for more than a century from quite different scientific points of view. A good summary of nearly one hundred and fifty years of scientific research on Baltic amber flora and fauna has been published by Larsson S.G. (Larsson S.G. 1978). In this monograph he tried to overview all groups of flora and fauna from Baltic amber and attempted to group them according to their living environments and biology. Later, a short summary of amber trees biotopes was done by Katinas V. (Katinas V. 1983). More detailed overview of inclusions from amber was published by Poinar G.O. (Poinar Jr.G.O. 1992). A controversial picture of amber forest has been presented by Lourenco W.R. and Weitschat W. (Lourenco W.R., Weitschat W. 1996). There they explained why a fossil scorpion *Palaeochylas balticus* (which has closest recent living relatives in the tropical forests of South – East Asia, North Australia, Indo – Malayan region and some parts of Africa) might live in usually judged as subtropical or even Palaearctic or Nearctic (Ander K., 1942) climate of today amber forests. Baltic amber forest was immense, covering large areas of what is now Scandinavia and northern Europe almost to the Urals (Poinar G.O., 1992, p.265).

In my work I will classify amber pieces with groups of inclusions inside (with more than seven inclusions) into three groups, using a modified system of Larsson S.G., in order to find out which part of the amber tree particular piece of amber with inclusions has come from.

Materials and methods

About 3000 pieces with inclusions from Palanga amber museum were investigated, from which only 100 pieces of amber with inclusions had more than seven inclusions inside. Those were examined more detailed by binocular microscope. Systematic position was determinate till the level of families. Generally, in Baltic amber from Palanga amber museum amber contains 1.3 inclusions per piece. The biggest one examined by me has 95 specimens of different inclusions inside.

Description of zones

A vertical layering can be observed in an amber forest. Conditions of light and humidity in this forest must have varied from the base of a tree to the treetops. There can be separated three zones in the amber forest: "*Sciara*" zone, the tree-trunk zone and the crown of a tree zone.

"*Sciara*" zone

Among the amber fossils, there is large number of one biological type from that animal life which has been widely distributed in the forest floor. This is the type of animal, which lives larval live in rotting vegetation and adult's existence free in the vegetation of the forest undergrowth. The most characteristic representatives are Diptera Sciaridae – fungus gnats. Others, belonging to this wet, filled with mold-forming plant material were