

THE DISTRIBUTION OF NATURAL BITUMEN IN ESTONIA

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Kattai, V., Lokk, U. and Suuroja, K., 1994. The distribution of natural bitumen in Estonia. Bull. of the Geological Survey of Estonia, 4/1, 12-16.

Notices about natural bitumen in Estonia are known already from the middle of the XIX century. During 1912-1924 oil prospecting was carried out repeatedly on Hiiumaa Island but the results are unknown. At present the total number of oil- and bitumen-shows reaches up to 170, two third of which are found in Hiiumaa. The Lower Proterozoic crystalline rocks of Kärda structure in Hiiumaa are regarded as the oldest bitumen-bearing rocks in Estonia. In Palaeozoic rocks the shows are known from Lower Cambrian to Upper Silurian. Their areal and stratigraphical distribution is irregular. The greatest number of appearances occur in Kukuruse, Idavere, Rakvere, Nabala, Põrgu (Ordovician) and Raikküla (Silurian) Regional Stages. Three areal zones of the highest natural bitumen accumulation can be distinguished: Northeastern Estonia, the western part of Estonian mainland and Hiiumaa. In Northeastern Estonia the bitumen-shows have been recorded in Lontova, Latorp, Lasnamägi and Kukuruse Regional Stages. In the western part of Continental Estonia the bitumen-shows locate in 20 km wide latitudinal zone which is traced up to Lake Peipsi. In this area natural bitumen occurs in Ashgillian and Llandoveryan rocks. The richest district for bitumen-shows is Hiiumaa where natural bitumen occurs in the rocks from Kunda to Adavere Regional Stages.

Key words: natural bitumen, Ordovician, Silurian, Hiiumaa, Estonia.

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Estonia was the first country of the Baltic region where natural gas, oil and natural bitumen (NB) were found. Notices of them are known already from the middle of the XIX century (Ozerski, 1844; Eichwald, 1852; Helmersen, 1857; Grewingk, 1868 etc.). In these and the later published works (Doss, 1900, 1914; Öpik, 1930; Kogerman, 1933 etc.) few solid bitumen findings from natural and artificial outcrops of Cambrian, Ordovician and Silurian sedimentary rocks have been described. Later viscid NB was found on Hiiumaa and Saaremaa Islands (Paasikivi, Zakashanski, 1965; Palmre, 1967). During the geological mapping of Hiiumaa in 1968-1971 NB occurrences were recorded also in the crushed crystalline basement near ground surface (Kala et al., 1978; 1984). Liquid bitumen (oil) has been mentioned rarely. Presumably it was first found in 1905 during hydrogeological drilling near Vaemla manor (Hiiumaa) at the depth of 40.5 m (Scupin, 1924). Oil prospecting was repeated in the same district during 1912-1924. In 1922 66 suits were handed in to the Estonian government by legal and individual persons. The results of the prospecting are unknown (Einpaul, 1961).

By 1965 the number of the known oil and NB appearances was 25. During the next 30 years many new appearances were recorded in the course of geological exploration and mining. At present the total number of such places (natural outcrops, quarries, mines, drill cores) reaches up to 170, two third of which are located in Hiiumaa.

The Lower Proterozoic crystalline rocks of Kärda structure in Hiiumaa are regarded as the oldest bitumen-bearing

rocks. The basement has raised to the depth of 15-60 m from the ground surface (normally 250 m) and has been strongly crushed due to impact at Middle Ordovician Idavere age. The viscid NB occurs locally in veins and caverns of migmatite- and granite-gneisses or granitoids at the depth of 15-181m.

In Lower Palaeozoic sedimentary complex the NB appearances have been established from Lower Cambrian to Upper Silurian (Fig. 1, 2).

Lower Cambrian. Two appearances have been mentioned in the Lower Cambrian rocks, both in the blue clay of Lontova Regional Stage (E_1 ln). A rather small (15×2 cm) lens of solid bitumen was found in Kunda quarry, and a similar one from an artesian well in Tallinn (Kogerman, 1933).

Lower Ordovician. Lens-like inclusions of solid bitumen have been established repeatedly in the glauconitic sandstone of Latorp Regional Stage (O_1 lt) in Northern Estonia (Helmersen, 1857; Doss, 1914; Müürisepp, 1962). P.Kogerman (1933) points to vertical asphaltitic veins in the glauconitic limestone of Volkhov Regional Stage (O_1 vl) in Vanamõisa outcrop. The lenses of black shiny solid bitumen occur also in many outcrops of coeval rocks (Babino, Putilovo) in St. Petersburg (Leningrad) District (Lyutkevich et al., 1964; Sakalauskas, 1968).

In the far northwestern part of Hiiumaa viscid NB has been recorded in caverns and as impregnation patterns in the limestone of Kunda Regional Stage (O_1 kn).

Middle Ordovician. NB has been found in all the stages

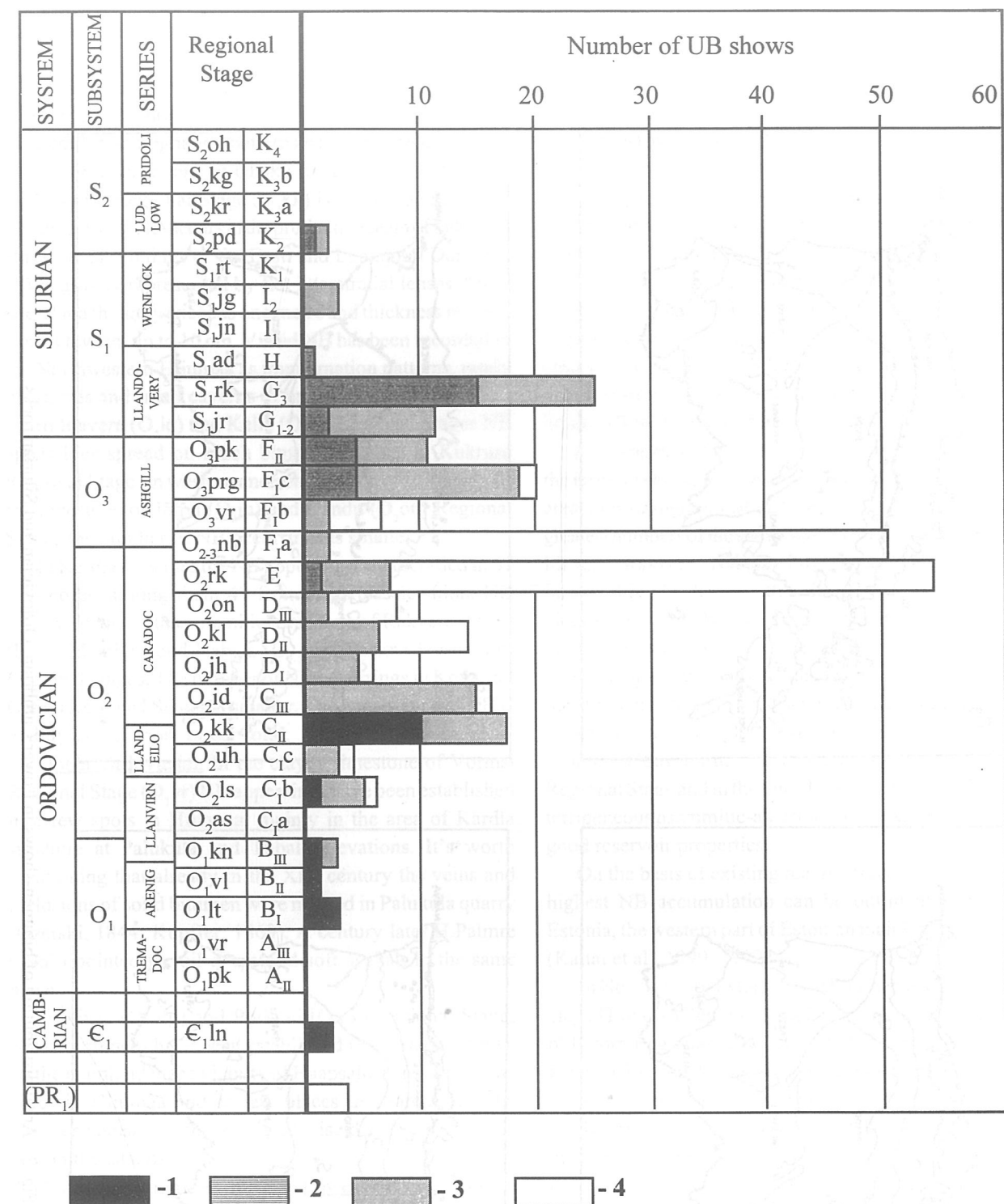


Fig. 1. Stratigraphical distribution of bitumen-shows in Estonia. 1 - Northwestern Estonia, 2 - western part of Estonian mainland, 3 - Hiiumaa, Saaremaa (except Kärda structure), 4 - Kärda structure.

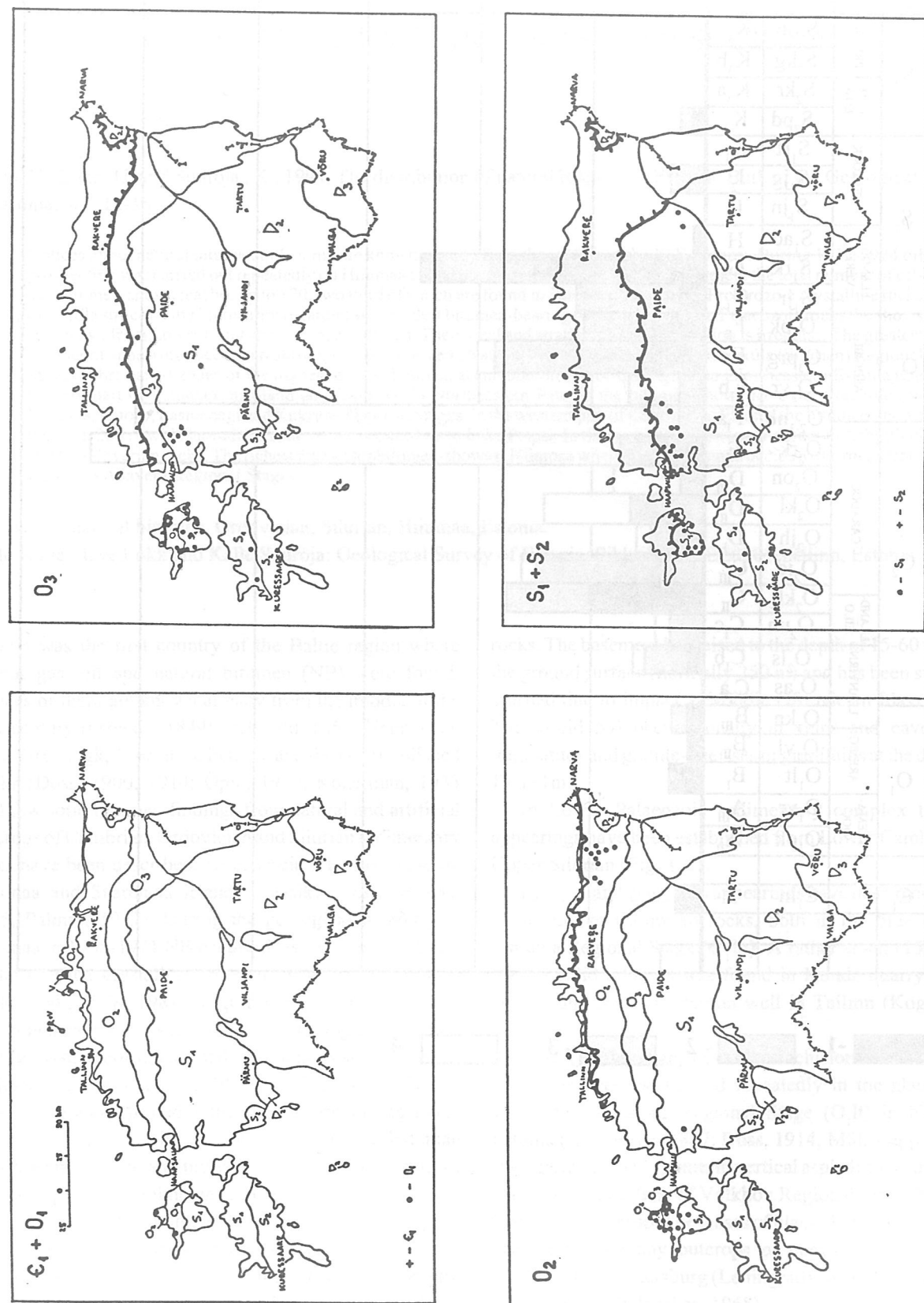


Fig. 2. Areal distribution of bitumen-shows in Lower Cambrian, Ordovician and Silurian rocks.

except Aseri Regional Stage (O_{2as}).

In Lasnamägi Regional Stage (O_{2ls}) viscid and solid NB occurs in small caverns and as impregnation patterns in limestone in the northwestern part of Hiiumaa. In the same area similar impregnation patterns have been recorded also in the clayey limestone of Uhaku Regional Stage (O_{2uh}).

Kukruse Regional Stage (O_{2kk}) is one of the richest in NB appearances. NB occurs in the productive seam of kukersite almost in all minings of the Eesti and Leningrad Deposits. NB is usually represented by flat interstratified lenses. Their lateral reach rarely exceeds one metre and thickness reaches from a few cm up to 10 cm. Viscid NB has been recorded in the Northwestern Hiiumaa as impregnation patterns, rarely in fissures and small caverns of limestone.

In Idavere (O_{2id}) and Keila (O_{2kl}) Regional Stages NB appearances spread on much bigger area than in Kukruse Regional Stage (in western and central parts of Hiiumaa). In the limestone of Jõhvi (O_{2jh}) and Oandu (O_{2on}) Regional Stages the number of NB occurrences is smaller.

In Kärkla structure the NB appearances are recorded in 67 drill cores, among them 47 from Paluküla elevation. NB mostly occurs in the aphanitic limestone of Rakvere (O_{2rk}) (Piitse Member) and Nabala ($O_{2,nb}$) (Paekna Formation) Regional Stages. The number of NB occurrences in Keila and Oandu Regional Stages is smaller. The consistence of NB is mainly viscid, more rarely solid.

Upper Ordovician. In the clayey limestone of Vormsi Regional Stage (O_{3vr}) NB appearances have been established in a few spots in Hiiumaa, mainly in the area of Kärkla structure at Paluküla and Tubala elevations. It's worth mentioning that already in the XIX century the veins and inclusions of solid bitumen were noticed in Paluküla quarry (Ozerski, 1844; Kupffer, 1869). A century later H. Palmre (1967) pointed to oil drops and soft asphalt in the same place.

In Põrgu (O_{3prg}) and Porkuni (O_{3pk}) Regional Stages NB occurrences have been established in Western Estonia: on the mainland in the vicinity of Haapsalu, in many drilling cores in Hiiumaa and in few places in Saaremaa. Solid bitumen appears on the mainland, viscid and oil-like liquid NB on the islands.

The distribution area of NB in **Lower Silurian** carbonate rocks almost coincides with its distribution in Upper Ordovician (Fig. 2). In Juuru Regional Stage (S_{1jr}) NB appearances have been recorded mainly in Southern Hiiumaa and single ones in the western part of the mainland and in its eastern part near Lake Peipsi. In Hilliste Member (Juuru Regional Stage) the frequency of occurrence of reef structures is very high. The reefs (mainly corals) are often impregnated and their cavities are filled with liquid, viscid or solid NB.

In Silurian carbonate rocks the greatest number of NB shows has been recorded in Raikküla Regional Stage (S_{1rk}). They occur mostly in the western part of Estonian mainland and in the southern part of Hiiumaa, single NB appearances

have been recorded in Saaremaa. Some NB occurrences have been established also in the clayey limestone of Adavere Regional Stage (S_{1ad}) in Southern Hiiumaa and in the dolomite and dolomitized limestone of Jaagarahu Regional Stage (S_{1jg}) in Saaremaa. At present no shows are known in Jaani Regional Stage (S_{1jn}).

In **Upper Silurian** NB presumably occurs on stylolitic and discontinuity surfaces in Paadla Regional Stage (S_{2pd}) in Saaremaa and in the western part of the mainland.

The nature of the occurrences in Ordovician and Silurian carbonate rocks is identical: impregnation patterns and stripes; fracture, pore, cavern and skeleton fillings. In Upper Ordovician and Lower Silurian solid NB has been established mainly on Estonian mainland, viscid and oil-like liquid NB in West Estonian archipelago.

As it appears from the above mentioned, NB occurs in the large stratigraphical interval on Estonian territory but its areal and stratigraphical distributions are not uniform. The greatest numbers of the shows have been recorded in Kukruse, Idavere, Rakvere, Nabala, Põrgu and Raikküla Regional Stages (Fig. 1). In fact, this does not reflect the factual picture very exactly. The present situation has developed mainly due to the extensive opening of the kukersite productive seam in Eesti Deposit (hundreds of sq. km) and numerous drill cores from the district of Kärkla structure. The NB appearances are completely missing in the interval from Vendian Gdov Formation to Lower Ordovician Pakerort Regional Stage and in the thick Lower and Middle Devonian terrigenous psammitic-aleuritic complex, characterized by good reservoir properties.

On the basis of existing records three areal zones of the highest NB accumulation can be outlined: Northeastern Estonia, the western part of Estonian mainland and Hiiumaa (Kattai et al., 1990; 1992).

In Northeastern Estonia solid bitumen occurs in the blue clay of Lontova Regional Stage, in the glauconitic sandstone of Latorp Regional Stage, in the kukersite and limestone of Kukruse Regional Stage and in the limestone of Lasnamägi Regional Stage - 18 cases in all.

The richest district for bitumen shows is Hiiumaa (119 occurrences). From the standpoint of areal distribution, three zones where NB appears in characteristic stratigraphic levels can be outlined there (Kattai et al., 1992).

Conventional northern zone embraces the northwestern part of the island. It is bordering on the region of Kärkla structure in the east and extends into the Baltic Sea in the west. The NB occurrences are associated predominantly with the Middle Ordovician rocks. Total thickness of the bitumen-bearing interval reaches 40-50 m in places. In stratigraphical section the distribution area widens from the west to the east. The bitumen-bearing rocks are embedded in the depth from some tens of metres in the north up to 100-150 m in the central part of Hiiumaa.

On the slopes and the crest of Kärkla structure and in the surrounding area NB almost without exception occurs in

postimpact carbonate rocks at the depth of up to 50 metres. The NB shows occur mainly in Rakvere and Nabala Regional Stages. It should be mentioned once again that in this area NB has been observed also in the rocks of crystalline basement.

In the southern zone of Hiiumaa the bitumen-bearing interval includes Upper Ordovician and Lower Silurian carbonate rocks with total thickness of 10-50 m. In this zone no NB shows have been recorded in the Lower and Middle

Ordovician rocks. Depth of the bottom surface of the NB-bearing complex increases from 10-20 m at the northern border of the zone up to 60-70 m in the south.

The southern zone of Hiiumaa extends to the mainland where 25 shows are located in Western Estonia in the latitudinal zone 20 km in width which is traced to Lake Peipsi by a few shows. In this district NB has been observed in Upper Ordovician and Lower Silurian rocks.

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