Stratigraphical and paleontological supplements on the Kukruse stage of the Ordovician Rocks of Eesti (Estonia).

1. Stratigraphy of the Kukruse stage.

Since the appearing of my memoir[1]) "The Kuckers stage etc." a set of borings in the kukersite district near Kukruse, Kohtla, Vanamõisa etc. have revealed new material on the stratigraphy and paleontology of the Kukruse (-Kuckers) stage.

I must express my warmest thanks to Dr. G. Elles for the examination of the graptolites.

The beds of the Kukruse stage may be divided: 1) into a lower portion — kukersite beds (seams) with thin bituminous limestone or limestone intercalations, beds I—XII, and 2) upper portion — bituminous limestone and limestone with thin kukersite partitions, beds XIII—D_1 (Jõhvi stage).

These series of beds can be mapped, at least in the Kohtla—Kukruse—Jõhvi district. (See geol. map.) The outcrop of the Kukruse stage in the last named district, constructed upon data of borings, differs considerably from the outcrop given on the map of Krutikov (reproduced in my memoir of 1921). The outcrop of this stage is rather narrower. The Jõhvi (D_1) limestone extends more to the western direction and slightly more to north.

For the description of different beds of the Kukruse stage are roman numbers very convenient.

For convenience of description the Kukruse stage might be divided: 1) lower, 2) middle and 3) upper beds. All these subdivisions of the Kukruse stage begin with kukersite beds. The kukersite in the upper beds of this stage has been lately discovered. (See table 4, p. 7.)

1) H. Bekker "The Kuckers stage of the Ordovician Rocks of N. E. Estonia". Acta et Comment. Universit. Dorpatensis. A II.1. 1921.

The character and thickness of the different beds of the lower portion of the stage in the kukersite quarry of Kohtla is seen on the table 1 (p. 5). The kukersite beds thin out to west. At Kehra the thickest kukersite bed attains only 0.13 m. (see table 2, p. 5); in north western Eesti the thickness of the stage diminishes (table 3, p. 6). It appears after data of borings that the stage thickens slightly in the southern direction, where the bituminous limestone beds of the upper portion of the Kukruse stage grow thicker (see table 4 and 4a, p. 7—8) and where in the upper portion have been discovered new kukersite beds.

The so called productive kukersite seams of the Kukruse stage end with bed XVIII; there are also higher up thin kukersite beds, and kukersite interbedded with limestone, discovered by borings near Arvila-Ratva, near Tudulinna. The best (for technical purposes) kukersite beds show a more or less uniform thickness from Jõhvi — Vanamõisa, but at Kehra they are replaced by bituminous limestone. The lower kukersite seams I, V, VII, which contain masses of bryozoa and other calcareous remains of different fossils, grow thinner in the direction of Vanamõisa.

All the measurements on the tables are in m.

The dip of the Kukruse stage in *S* direction is 11′—13′.

2. Zones of the Kukruse stage.

The faunal elements of the different beds of this stage distinguish four zones.

1) Bryozoan zone. The kukersite beds I, V, VII and the bituminous limestone intercalations contain masses of bryozoa. In the beds I and V are especially abundant: *Chasmatopora*, *Pseudohornea*, *Graptodictya* etc. In the bed VII among others *Eridotrypa*. For the bed VII are very characteristic in the upper face worm tracks. Thickness of the zone: 0.38—2 m.

2) Coelosphaeridium zone. This thin limestone bed VIII is very remarkable. It is very slightly bituminous (0.8 %); it can be traced horizontally for a considerable distance. (See Fig. 1, 2.) The limestone shows worm tracks on its lower face. The fauna differs considerably from the associated calcareous and kukersite beds. It contains the calcareous alga *Coelosphaeridium kohtlense*, allied forms of which are met abundantly

higher up in the Jõhvi stage (D_1); *Lingula* is here rather abundant; *Climacograptus* cf. *kuckersianus* very rare. The thickness of this zone is rather uniform: 0.2—0.3 m.

3) Brachiopod zone. Different brachiopods mark here the kukersite and bituminous limestone beds. In the kukersite bed IX is more or less abundant *Clitambonites* (this brachiopod is also rather abundant in bed VII); the bituminous limestone bed X is composed, to a great portion, by valves of *Plectambonites sericea*, which is one of the most common brachiopods also in some other beds.

The kukersite bed XII contains an abundance of different *Porambonites*. In the bituminous limestone higher up, is quite common *Leptaena estonensis*. Thickness of the zone: 2.5—3.1 m. But all of these brachiopods can be found in the other zones of the Kukruse stage, however less abundantly.

4) Mesograptus and Climacograptus kuckersianus zone. Higher up follows bituminous limestone XVII—XXIII with occasional grey-blue limestone layers and thin kukersite beds (0.05—0.08 in the upper portion). At Vanamõisa the lower beds of this zone contain: *Mesograptus* cf. *modestus*, *Climacograptus* cf. *kuckersianus* associated with *Chasmops odini* and other fossils. At Idavere the upper beds yield: *C.* cf. *kuckersianus*.

Thickness:	Vanamõisa	Järve	Jõhvi	Apandik
	4.59	7.37	8.93	10.61

3. Origin of the kukersite.

At a meeting of the Institution of Petroleum Technologists have been discussions on the origin of the kukersite. Cunningham Craig[1]) (p. 9) strongly believes, "we can only conceive of such a rich oilshale being formed by impregnation with inspissated petroleum".

Let us see the results of chemical investigation of prof. M. Wittlich and S. Veshnjakow[2]) (p. 10) on the different beds (I—XII) of the Kukruse stage at Kohtla. (See table 5, p. 10.)

Supposing that the oilshale was formed by impregnation, we must have a deposit (usually clay), which could be impregnated. The only material in the kukersite which possibly could inspissate petroleum is SiO_2, Al_2O_3, Na_2O, K_2O — derived from Felspar rocks. But the percentage of these particles in the

kukersite is very unimportant. (See table 5.) The *CaO* in the kukersite beds is mainly due to the calcareous sceletons of different fossils; studying thin sections of these, we see that only the cavities and hollows are filled by kukersite; the calcareous layers and tissues of the fossils are unable to inspissate oil. The % of the clayey material is nearly the same in the "Building limestone" VIII and kukersite bed V. This bed (V), 0.5—0.7 m. thick, contains clayey material 12.7%. The imagination must work greatly to thicken a thin clay deposit of a few centim. to the thickness of 0.7 m. by impregnation of petroleum.

These chemical considerations make us still believe that the kukersite is mainly an algal deposit, as have shown microscopical studies of Fokin, Zalessky, Bekker, Lindenbein.

Kogerman[1]) thinks that "probably 3 processes took place side by side during its formation: 1) decomposition of the original organic matter, 2) oxidation of decomposition products and 3) adsorption".

4. Correlation of the Kukruse stage.

I sent a number of specimens of *Plectambonites sericea* and *P. sp.* to prof. O. T. Jones, who works on a monograph of the gen. *Plectambonites*. He expresses his valuable opinion in a letter as follows: „The ribbing in these specimens is almost identical with the earliest form of the genus which occurs in Britain in the Llandeilo limestones immediately above the Didymograptus murchisoni zone. It is slightly more differentiated but not to the same extent as in the Caradoc forms which occur (on the graptolitic scale) just above the Nemagraptus gracilis zone. The internal characters and to some extent the size and shape more nearly agree with the Caradoc specimens. All of them, however, are slightly more transverse than the British types. If, therefore, the development of the forms in Estonia has proceeded on parallel lines to those in Britain, the Kuckers stage would appear to lie about midway between the lower Llan-

1) P. N. Kogerman "The Chemical Composition of the Estonian M-Ordovician Oil-bearing Mineral Kukersite". Acta et Comment. Univ. Dorpatensis, A. III. 1922.

deilo limestones and the Lower Caradoc beds. They would probably therefore be slightly earlier than the *Nemagraptus gracilis* beds".

5. New Fossils from the Kukruse stage.

Coelosphaeridium kohtlense sp. n.

Pl. I, f. 11.

Diagnosis. Shape of this alga almost sphaerical. It shows clearly a stem for attachement. The cells are of regular sixangular shape, rather large. The central radials are not preserved.

Locality and horizon: In the "Building" limestone, bed VIII. At Kohtla.

Measurements: Diameter . . . . . 1.8 cm.
„ of the cells . . 1—1.25 mm.

Description: In transverse section the sphaerical bodies show the characteristic triangular cell walls of the gen. *Coelosphaeridium*. (See: Dr. E. Stolley "Neue Siphoneen aus baltischem Silur", 1900. Arch. f. Anthrop. u. Geol. Schlesw.-Holst., p. 61.)

The central pores in the bottom of the cells are not well seen in this species.

Relation. The species is undoubtedly related to *C. excavatum* Stolley from the Echinosphaerite limestone (C_1). It differs by its larger size, as well as by its twice larger cells.

Climacograptus cf. *kuckersianus* Holm.

Pl. I, f. 1—7.

Climacograptus kuckersianus Holm, 1896, C. Wiman "Über die Graptolithen" Bull. Geol. Inst. Univ. Upsala, vol. II, p. 275, pl. IX, f. 2 and pl. X, f. 1—5.

Locality and horizon: In the bituminous limestone above the kukersite bed XVIII. Kukruse stage (C_2).

Measurements: Length of fragmentary specimens 14—22 mm
Width of polyparies . . . . 1.5—1.75 „
In 10 mm . . . . . 12—14 thecae.

Description: Dr. G. Elles kindly examined the graptolites, and she thinks: "there are certainly numerous specimens of a form which may be *kuckersianus*, though they differ from Holms figure in some important particulars:

1) The graptolite is a larger one than Holm's figures indicate, and most of the specimens are more parallel sided right

down to the proximal end than the specimen figured, this however may be a slight variation, perhaps a real variety, as some specimens vary slightly in this respect;

2) the basal thecae grow more obliquely than do those in Holms figure, and this no doubt accounts for the greater relative breadth at the proximal end;

3) the septum does not originate between the second but between the third thecal pair.

It is a graptolite of the *Cl. rectangularis* type that differs mainly from that form in its parallel sidedness and deeper

Fig. 3.

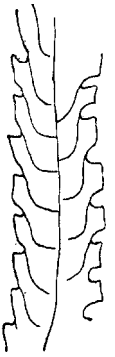

Fig. 4.

Fig. 5.

Fig. 3—5. *Climacograptus* cf. *kuckersianus* Holm×8

apertural excavations (this last may be affected by preservation). It is a coarser form altogether than *Cl. normalis*, which it resembles in its parallel sidedness."

Mesograptus modestus G. Elles and M. Wood.

Pl. I, f. 8—9.

Mesograptus modestus G. Elles and Wood, 1901—18, British Graptolites, Palaeontographical Society.

Material: Several fragmentary and 1 nearly complete specimen. Author's collection.

Locality and horizon. In the bitum. limest. above the kukersite bed XVIII. *Mesogr. modestus*, *Cl. kuckersianus* zone. Kukruse stage (C_2).

Measurements: Width of polypary . . . . 1.25 mm.
Lenght of nearly compl. specimen. . . . . 10 mm.
In 10 mm . . . . . 13—16 thecae.

Description: Thecae of the proximal end overlap $^1/_2$ of their length. Their free edge is inclined and with short spines. Sigmoid curvature of ventral edges of the thecae is more expressed in the proximal end, than in the distal end of the polypary; at the latter the length of the thecae is greater and their free edges are nearly vertical.

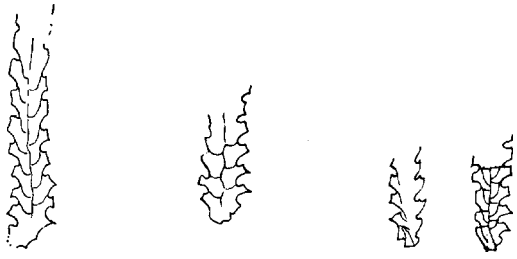

Fig. 6a. Fig. 6b. Fig. 6c.

Fig. 6. *Mesograptus modestus* × 8 — a) nearly complete polypary; b) fragment of a polypary; c) two other fragments of polyparies, with sicula (reverse aspect).

Conularia trentonensis Hall.

Pl. I, f. 12.

Conularia trentonensis Hall, 1847, Pal. of New York, pt. I, p. 222, Pl. LIX, f. 4.

Original description: "Pyramidal, obtusely quadrangular; angles sulcate; sides somewhat rounded; a slightly impressed line along the centre of each side, from the apex to the base; surface marked by sharp obliquely transverse ridges, which, extending from each angle of the shell towards the mouth, meet those from the opposite angle in the centre of each side, producing a slightly impressed line, along which the ridges are less prominent; longitudinally marked by finer striae, which are slightly convergent towards the angles, and divergent from the centre of each side (these striae are most prominent in the depressions between the transverse ridges); septa transverse, very convex, smooth; siphuncle excentric.

. . . The shell at the angles seems to be slightly folded inward producing a groove, which interrupts the transverse ridges . . .

Position and locality: In central and higher part of the Trenton limestone at Middleville, Jacksonburgh, Trenton Falls and other places."

The Kukruse specimen corresponds exactly with the above description except that the septa and siphuncle are not seen.

Material: Author's collection, 1 specimen.

Tahvel I. — Plate I.

		(Kukruse lademe pealmised kihid.)
Joon. (Fig.) 1.	*Climacograptus* cf. *kuckersianus* Holm	*(Highest beds of the Kukruse stage.)*
		Koht (*Local.*): Idavere.
„ „ 2.	„ „	Vanamõisa.
„ „ 3.	„ „	„
„ „ 4.	„ „	„
„ „ 5.	„ „	„
„ „ 6.	„ „	„
„ „ 7.	„ „	Kohtla (VIII kiht; *bed VIII).*
„ „ 8.	*Mesograptus modestus* G. Elles and M. Wood	Vanamõisa.
„ „ 9.	„ „	„
„ „ 10.	*Leptaena estonensis* Bekker	Ventraalkaas; *Ventr. valve.* Kohtla.
„ „ 11.	*Coelosphaeridium kohtlense* sp. n.	Sfääriline vetikas ja selle ristlõik. *The sphaerical alga and its transverse section.*
„ „ 12.	*Conularia trentonensis* Hall.	11 – 12 Kohtla; kiht *(bed)* VIII.
„ „ 13—14.	*Lingula* sp.	Kohtla; kiht *(bed)* VIII.
„ „ 15.	„ „	Kaane struktuur. *Surface structure* × *1.5*

Tahvel II. — Plate II.

Joon. (Fig.) 1. Graptoliite sisaldava bituminoosse lubjakivi struktuur. *Microscopical structure of the bituminous graptolites containing limestone.*

The section shows calcium-carbonate crystals of more or less uniform size; in this ground matrix are embedded colonies of Gloeocapsamorpha prisca Zalessky, of yellow-brown colour; these colonies are in a fairly large number and result the yellowish-brown colour of the limestone as also its bituminous character. Debris of fossils, composed of calcium-carbonate and minute particles of quartz or other minerals are very scarce.

Joon. (Fig.) 2. "Kahekordse pae" VIII struktuur. *Structure of the Coelosphaeridium limest. (bed VIII).*

This limestone of blue-gray colour, is mainly composed of debris of different fossils and to a small portion of small angular or wave-rounded particles of quartz or other minerals. As inclusions of this ground matrix we see in a very limited number black spots (under the microscope of yellow-brown colour) — colonies of Gloeocapsamorpha prisca.

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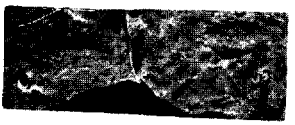

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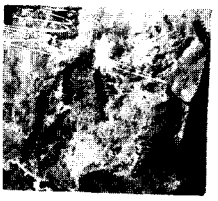

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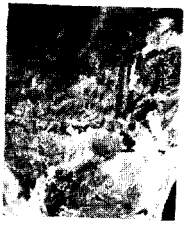

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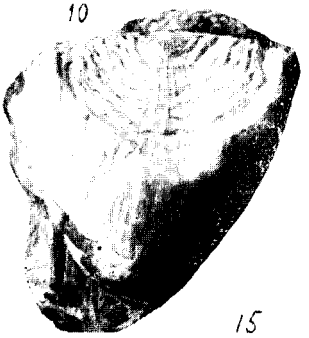

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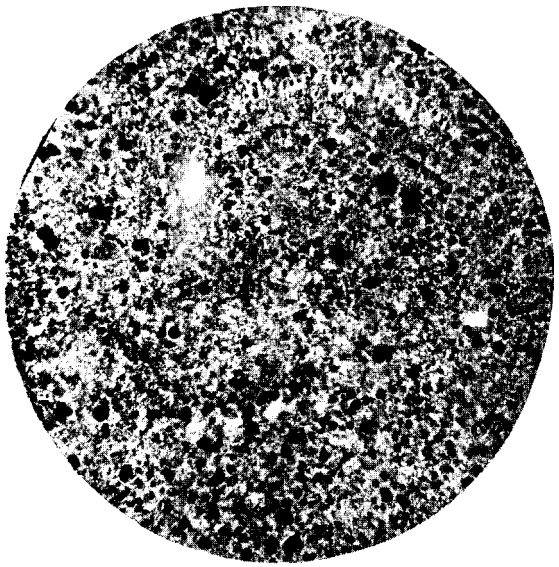

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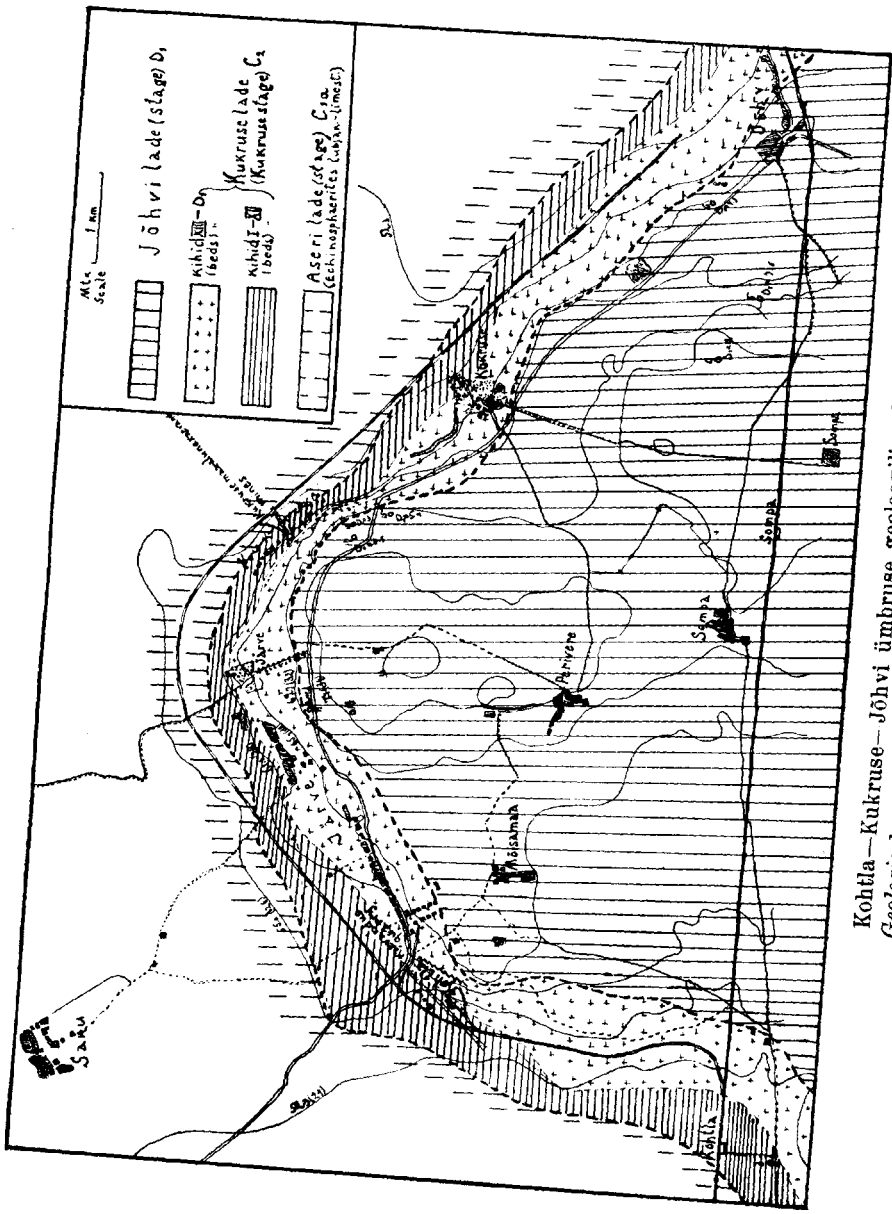
K. Mattiesen'i trükk, Tartus.



Kohtla—Kukruse—Jõhvi ümbruse geoloogiline kaart.
Geological map of the District Kohtla—Kukruse—Jõhvi.

K. Mattiesen'i trükk, Tartus.