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DISCOVERY OF ORDOVICIAN LAND PLANTS
(Preliminary communication)

Abstract. — In Ordovician erratic boulders land plants remains were found. They could be considered as more primitive than Psilophytales, and probably as the most primitive land plants. Two new genera: *Musciphyton* gen. nov. and *Hepaticaephyton* gen. nov. are distinguished.

I. INTRODUCTION

by
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For the purpose of etching from Ordovician calcareous rocks graptolites and other animals with chitinous skeleton the present writer has, for many years past, used the hydrochloric and acetic acid treatment. Recently, during this work, he has discovered plant remains of particular interest.

The rocks which have yielded these organisms are erratic boulders carried to Poland from Scandinavia and the Baltic region by Pleistocene glaciers. Besides pulverized or minute fragments of calcareous animal skeletons, they practically always contain numerous remains of chitinous skeletons, such as Graptolithina, Annelida (jaws) and Hydroida. Occasionally they also yield plant remains. The majority of these are referable to Phycomycetes and Algae. They occur in association with a typically marine fauna and, most likely, were themselves marine organisms. Sporadically, however, among these aquatic plants, other remains are noted of higher organization and surely of continental origin. These specimens have attracted the writer's attention as evidence of particular interest.

During his visit, in the summer of 1958, to the Institute of Palaeontology directed by the writer, Professor P. Greguss from the Szeged University (Hungary) showed a keen interest in the mentioned material. These peculiar plant remains were, consequently, entrusted to him for investigation. The present brief report and theoretical speculations by Professor Greguss are introductory to a future more detailed description of these uncommonly interesting materials by this author.

The plants, for which Professor Greguss has introduced the new generic name of *Musciphyton* gen. nov., were extracted from a boulder (No. 0.225), 1.65 kg in weight, collected near Zakroczym, in the valley of the Vistula. It is a compact pelitic limestone, lithologically similar to the lithographic limestone of the Jurassic. This rock, familiar long since to geologists who study the erratic boulders of northern Europe, is by German writers referred to as "Ostseekalk". The graptolite *Orthograptus gracilis* (Roemer) is its most common index fossil. Its age most probably corresponds to that of the "Saunja" (F_1a) horizon, that is to the middle part of the Estonian Upper Ordovician. The mentioned graptolite has not been found by the writer in the boulder which has yielded *Musciphyton* gen. nov., but the lithological features of that rock prove beyond doubt that it is a typical "Ostseekalk". Fine calcareous dust constitutes the bulk of this limestone, and small concentrations of pyrite and organic remains are dispersed in the matrix. The organic remains contain silicified shells of Brachiopoda Articulata (Orthoidea and Plectambonitidae), phosphatic shells of Brachiopoda Inarticulata (*Conotreta* sp.), Conodonta, pyritized spicules of sponges, chitinous remains of Annelida (Scolecodonta), Hydroida and Chitinozoa. Among these animal remains occur fairly numerous thread-like aggregations of Phycomycetes, sometimes partly pyritized, but in most cases not displaying any fossilization.

Specimens of *Musciphyton* gen. nov. occur under most peculiar form. The majority constitute associations of several stems united, mostly at their base, by a matrix of mineral detritus. Unsorted quartz grains predominate, ranging from fine powder to 360 μ in diameter. The larger grains are usually rounded, the smaller — angular. In most cases the quartz is colourless, very rarely of milkish-pink or light mauve tint. Grains of glauconite and rare flakes of strongly weathered biotite also occur. The mineral detritus here is usually coated by iron oxides of an orange or red colour. The mineral associations cementing stems of *Musciphyton* are doubtlessly an alien element in the calcareous deposit. Most likely it is the substratum on which these land plants developed and together with which they were secondarily transported to a marine environment.

Dense associations of threads (hyphae) of Phycomycetes most likely referable to saprophytes, commonly occur on stems of *Musciphyton* and within the mineral detritus.

Boulder No. 0.241, one kg in weight, which has yielded plants, by Professor Greguss called *Hepaticaephyton* gen. nov., was also collected near Zakroczym. It is a limestone with granular texture, almost entirely made up of calcareous fragments of indeterminate Brachiopoda and tests of Echinodermata. Juvenile gastropod shells and less frequent conodont

denticles are encountered among these fragments. Chitinous remains are not common, being mainly those of Scolecodonta and Chitinozoa. Phycomycetes are abundant. The age of this boulder cannot be exactly determined on the animal remains it contains. Scolecodonta and Chitinozoa are common forms in Middle and Upper Ordovician boulders. Closer investigation of these remains may in the future lead to a more exact dating of this boulder. For the present, however, it is established as Ordovician.

The specimens of *Musciphyton* and *Hepaticaephyton* are wonderfully well preserved. After dissolution of the original calcite which impregnated the plant tissues, they have nearly a recent plant semblance. Their brown colouration is occasionally so faint that they are almost colourless, in other specimens it is stronger. The majority of stems are not compressed and have preserved their original plasticity. The contours of the large epidermal cells coating the surface are in most cases very distinct. After being etched the tissues of these plants, however, still remain more or less impregnated by quartz powder, partly also by that of pyrite which has not dissolved by acid treatment.

Abundant Phycomycetes, accompanying these plants, are likewise excellently preserved. There are mainly associations of very fine colourless hyphae, non-mineralized or occasionally in a varying degree filled or incrusted by pyrite. Their original plasticity has persisted here too. Numerous vesicles (sporangia) are attached to some of them. In appearance these Ordovician Phycomycetes resemble *Palaeomyces* which occur in the Middle Devonian of Scotland in association with silicified remains of Psilophytales. These plants must have been common in Ordovician seas, as they frequently occur in rocks of that age.

II. PROBLEM OF THE ORIGIN OF LAND PLANTS IN THE LIGHT OF NEW ORDOVICIAN FINDS

by

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Speculations on the nature of the first Cormophyta which started land vegetation, and on the period of Earth's history which witnessed the expansion of the vegetable kingdom are old unsolved problem in plant phylogenetics.

On today's palaeontological evidence we know that 250 million years ago, during the Carboniferous, there lived in co-existence trees of gigantic stature, namely the microphyllous Lycopsida, the macrophyllous Pteropsida and the whorl-leaved Sphaenopsida. Psilophyta, primitive plants in the

Middle Devonian, some 25 million years before the Carboniferous, were much smaller, hardly 0.5 m high, while plants 10 to 12 cm and even 1 to 2 cm in height occurred too.

The entirely bare *Rhynia* and *Hornea*, the microphyllous *Asteroxylon*, moreover the macrophyllous *Protopteridium* and *Calamophyton*, the last with its whorled branching, are known to have been contemporaneous.

The general opinion had been that the Devonian primitive plants were the simplest vascular plants and that from this common type three different groups of the Pteridophyta had developed, viz. Lysopsida, Pteropsida and Sphaenopsida. Another opinion, still now prevailing, is that not only the Pteridophyta but also the Psilophyta are represented by three principal types and that in turn these plants may have developed from three simpler types whose appearance may have occurred in earlier times.

According to W. Zimmermann's "telome theory" the ramification of the Pteridophyta can be traced back to the primitive dichotomy of simple Devonian plants, e.g. the monopodial ramification resulted from the outgrowing of one branch of dichotomy; on the other hand leaves were formed through the flattening of the telome, i.e. the "planation", while fork-like branching telomes became simple unramified shoots through the reduction of stems. In conformity with the "telome theory" Zimmermann supposes that dichotomy was the primitive branching form and that the two other branching types may have developed therefrom. Owing to the scarcity of pre-Devonian vascular plant finds, many research workers still consider the Psilophyta as the most primitive vascular plants, and the mosses as their descendants, since fossil mosses are known from the Upper Carboniferous only.

These theories, as well as that of Zimmermann, call for revision on the basis of examination of recent finds of Ordovician plant remains made by Professor R. Kozłowski. This discovery is of great importance in so far as it supplies reliable evidence that Ordovician plants were simpler than the Psilophyta. They are namely organisms from 2 to 8 mm high. Up to now, no such simple continental vascular plants have been known. *Aldanophyton* described by A. Kryshtofovich from a Middle Cambrian impression is as yet problematic.

The writer's studies of Ordovician plant remains, discovered by Professor Kozłowski, cover complete external and internal morphology, the branching types, structure of the vegetative shoot apex, and root apex, root hairs, structure and form of the superficial cells of stems, reproductive organs, the archegonium, the antheridium, the sporogonium, the spores, the fertile bud and, as far as possible, the internal anatomy in cross and longitudinal sections of stems. The four attached plates illustrate some of these observations. Plate I shows the appearance of these tiny plants

and their relative sizes. In plates II and III are figured characteristic representatives of the two chief new genera (*Musciphyton* gen. nov. and *Hepaticaephyton* gen. nov.). These are supplemented by camera lucida drawings of three species of *Musciphyton* gen. nov. (pl. IV).

The results of the writer's preliminary studies may be summarized as follows:

It has been ascertained that the Cormophyta have lived not only in the Devonian but much earlier too, as early as in the Ordovician. These Ordovician plants, being simpler than the Devonian Psilophyta, may summarily be called "Propsilophyta". Plants of this sort were possibly the first vascular plants to have started the vegetation of the Earth's land surface. Their height ranged from one to ten mm. The fact of the existence at that early period, side by side, of two different types of primitive plants: monopodial and dichotomous (pl. I, upper and lower rows), is of greatest phylogenetic significance. The writer must, however, confess not having observed complete specimens of both types.

Monopodial type. As is shown by photographs and drawings (pl. IV), the stems of that type were cylindrical and leafless, some without branching, others with monopodial branching. This is proved by the fact that branches of two different thickness were shot off the same stock (pl. II). These tiny plants, with or without branching, were highly similar to the taller Devonian *Psilophyton,* and to setae of our leafy mosses. Their surface was covered with thick-walled epidermal cells. Stomata had not yet developed. There were vegetative cones on the shoot apex (pl. II). Conductive bundles stretched along the middle of stems. Root hairs, in regular arrangement, were developed on subterranean parts (pl. II, fig. 1). The writer has succeeded to differentiate in the studied material some 12—14 specimens of this type on the basis of their external and internal structure. The generic name of *Musciphyton* gen. nov. is proposed because of their similarity to leafy mosses. A detailed description with the nomenclature of particular forms will be published in the next paper.

Dichotomous type. In this other type the body extends narrowly or widely (pl. I, lower row; also pl. III). The branching is always dichotomous only. These plants were similar to some types of Hepaticae, as well as to the Devonian *Taeniocrada, Zosterophyllum* and *Sciadophyton.* Hence they were given the generic name of *Hepaticaephyton* gen. nov. In the interior of their stem are conductive elements just as in *Psilophyton.* The conductive elements have simple pitted walls, indicating that some of these specimens belonged to the sporophyton generation. In some specimens lobes separated from stems, with assimilating hairs on their ends (pl. III). These specimens may possibly correspond to the prothallium. A detailed description and nomenclature will follow in the next paper.

Since the two fundamentally different types of mosses have lived simultaneously, and were in the same evolutionary stage, it seems soundly reasonable to revise the prevalent opinion which postulates the descent of one type from the other. At the same time must be dropped the supposition that mosses and our tiny moss-like plants may have developed by "reduction" from Psilophyta or Pteridophyta. This is quite impossible since the moss-like "Propsilophyta" lived at least 100 million years earlier than the Carboniferous Pteridophyta or the Devonian Psilophyta.

The here considered find does not supply evidence in support of the theory that the first land plants might have developed from larger sea algae. In the writer's opinion sea-weeds, particularly the Phaeophyta and Rhodophyta, by many students pointed out as ancestors of primitive land plants, reached their highest degree of development, analogous to that reached by land plants in the angiosperm stage, perhaps as early as in the Cambrian seas. This is furthermore proved by alternation of generations of highly developed sea-weeds. In some members of the Phaeophyta or Rhodophyta haplont and diplont series are noted in like manner as among land plants. Some of these sea-weeds reached their highest degree of development by the fact that the haploid generation is limited to some cells or to the reproductive cells only, while the diploid, i.e. the sporophyte generation grew to gigantic size as compared with the gametophyte (e.g. *Fucus, Laminaria*). The gametophytic (haploid) part of our seed plants is limited to the embryo sack and pollen grains, while the sporophyte generation is represented by the well developed root, stem, leaf and flower.

In the writers opinion, the land vascular plants, starting with the unicellular up to the highest form, have developed on the land quite independently, so that it is not in the least necessary to people the continents with descendants of the highly developed sea-weeds thrown out of marine environment. Many arguments may be advanced, chiefly physiological and morphological (differences of salinity, environment, light relations), refuting a land population by sea-weeds. From the structure of the above characterized Ordovician vascular plants hardly 1—10 mm in size, it must be reasonably inferred that the sea-weeds represent an independent process of evolution in the sea, while the land plants do so on the land. These two processes meet at the unicellular stage only. From this common unicellular stage the sea-weeds may perhaps, in the course of time, have developed to their modern highest stage, while the land plants, starting also from the unicellular form on the land, passed here their various evolutionary stages up to the angiosperm stage. On this assumption we must try to find the ancestor of the land vascular plants not among sea-weeds but on the land. Their starting evolutionary stage is to some degree demonstrated by the discovery of our tiny Ordovician plants. The exa-

mination of these plants proves the existence at that period, hence long before the development of Psilophyta, of non-branching, monopodial, and dichotomous forms of the stem body. These three forms lived simultaneously, therefore, the dichotomous branching form with flattened body, could not have developed from the monopodial branching form with cylindrical body, or conversely. It is not impossible that the ancestors of these branching forms existed previously, perhaps already in the Cambrian.

The whole organism of our Ordovician plants shows the probable form of the first continental plants and it is only with forms of so simple a structure that the vegetable kingdom could start its invasion of the continents.

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ODKRYCIE ORDOWICKICH ROŚLIN LĄDOWYCH

(Notatka wstępna)

Streszczenie

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OBJAŚNIENIA DO ILUSTRACJI

Pl. I

15 okazów różnych roślinek. W górnym rzędzie ułożono formy cylindryczne bez rozgałęzień rodzaju *Musciphyton* gen. nov. Ich wymiary podaje skala 1 mm. W rzędzie dolnym przedstawione są okazy *Hepaticaephyton* gen. nov., wielkości od 1,5 do 8 mm.

Pl. II

Musciphyton zakroczymense Greg. gen. et sp. nov.; roślinka o rozgałęzieniu monopodialnym: cylindryczne gałązki odchodzą od łodyżki różnej grubości. Łodyżka pokryta jest czworokątnymi komórkami o grubych ścianach. Na szczycie ryzomu znajduje się stożek wzrostu (w środku górnej części planszy). Chwytniki odchodzą od łodyżki. Wewnątrz łodyżki biegnie wiązka przewodząca.

Pl. III

Hepaticaephyton polonicum Greg. gen. et sp. nov.: roślinka rozgałęziająca się dychotomicznie. Z boku wyrasta płat z wielokomórkowymi chwytnikami na końcu. Wysokość 1,5 mm.

Pl. IV

1 *Musciphyton kozlowskii* Greg. sp. nov., 2 *Musciphyton vistulense* Greg. sp. nov., 3 *Musciphyton ramosum* Greg. sp. nov.

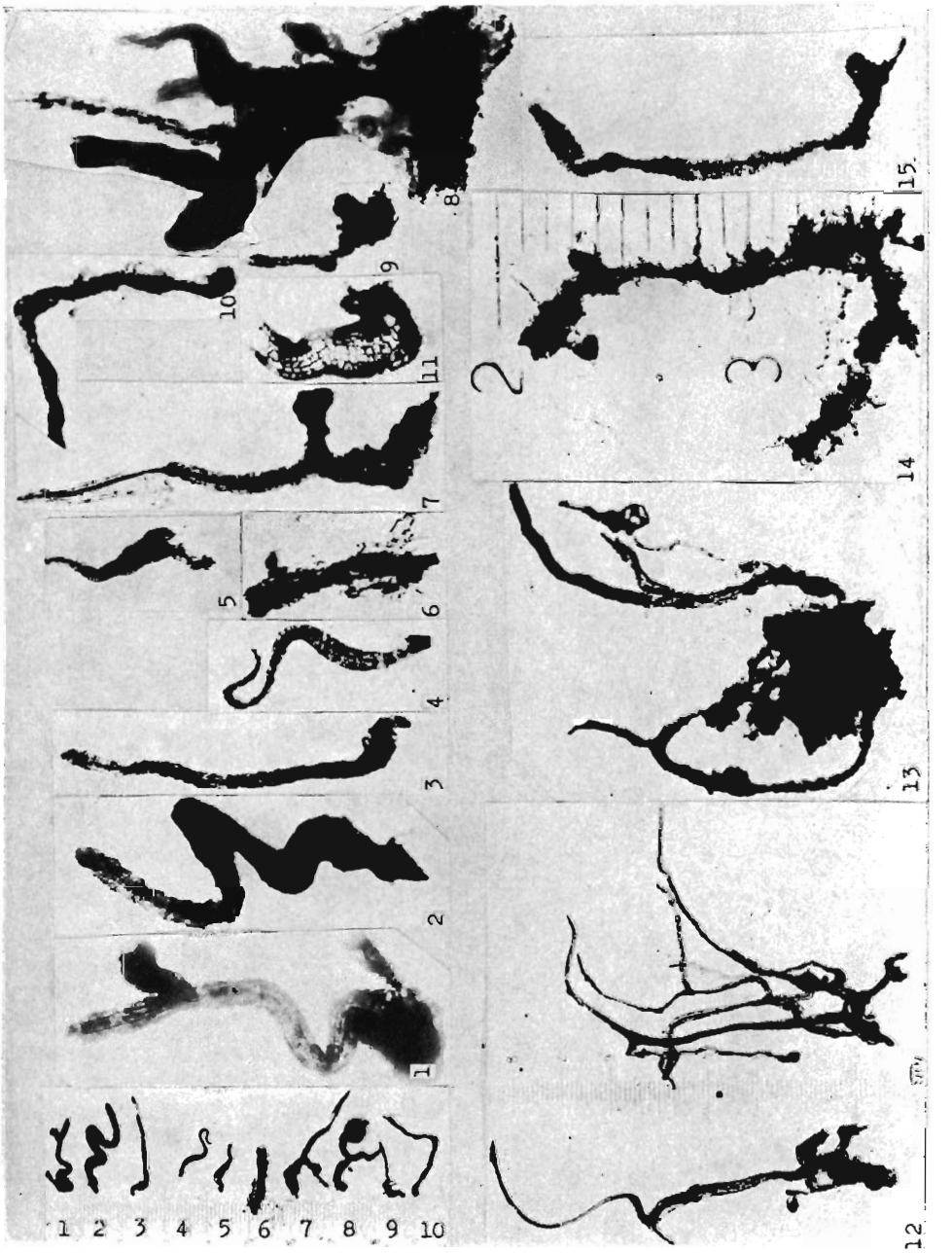
РОМАН КОЗЛОВСКИ & ПАЛЬ ГРЕГУШШ

НАХОДКА ОРДОВИКСКИХ НАЗЕМНЫХ РАСТЕНИЙ

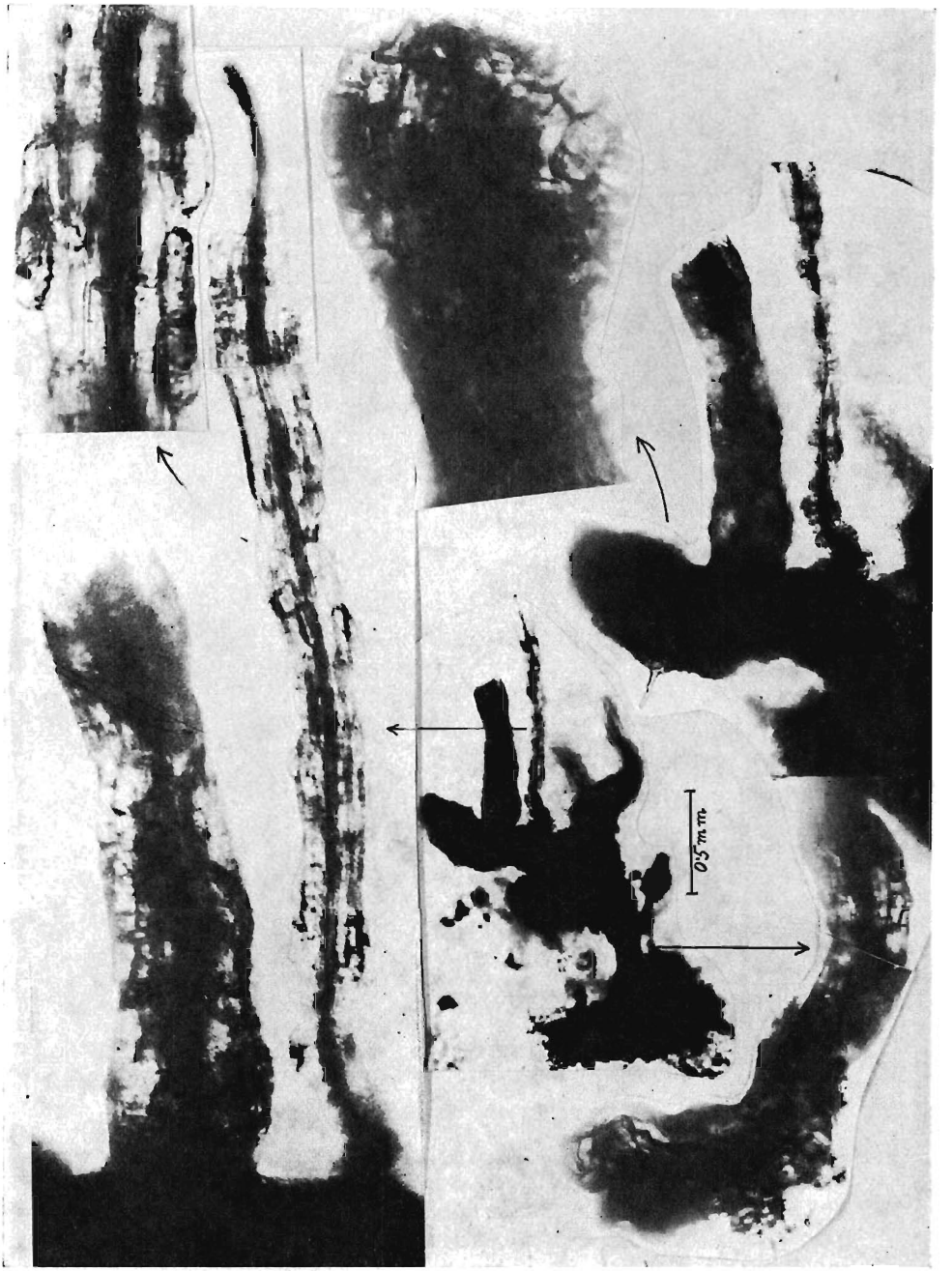
(Предварительная заметка)

Резюме

В настоящей заметке авторы сообщают о находке первым из них остатков ордовикских растений наземного типа. Эти материалы были отпрепарированы автором из ордовикских известняковых валунов, собранных в долине Вислы у Закрочима (30 км севернее Варшавы), растворяя их в соляной кислоте. Известняки эти, притащенные четвертичным ледником из Скандинавии, соответствуют морским осадкам и содержат остатки типичных морских животных, как то граптолитов, иглокожих, брахиопод, кольчецов (сколекодонты), гидроидов и т. п. Содержат они также низшие грибы и водоросли, по всей вероятности тоже морские. Среди этих организмов найдены однако некоторые растения более высокой организации, которые по мнению второго автора являются вне всякого сомнения наземными. Эти растения должны были быть принесенными в морской бассейн из побережья континента. Отличаются они исключительно совершенной сохранностью. Подробным их исследованием занялся второй автор и результаты его работы будут опубликованы в ближайшее время. В настоящей предварительной заметке автор сообщает, что исследоваемые им растения представляют два новых рода, которым дает названия *Musciphyton* и *Hepaticaephyton*, а группе, к которой возможно будет их отнести, дает предварительное название „Propsilophyta". Эти растения во многих отношениях более примитивны, чем Psilophyta, известные до настоящего времени из силура и девона. Вероятно они немногим отклоняются от теоретического прототипа наземных растений. Пока что автор ограничивается сообщением только общей характеристики двух выделенных им родов, иллюстрируя их фотографическими снимками и рисунками. В тоже время обсуждает значение этой находки для вопроса происхождения и эволюции наземных растений.

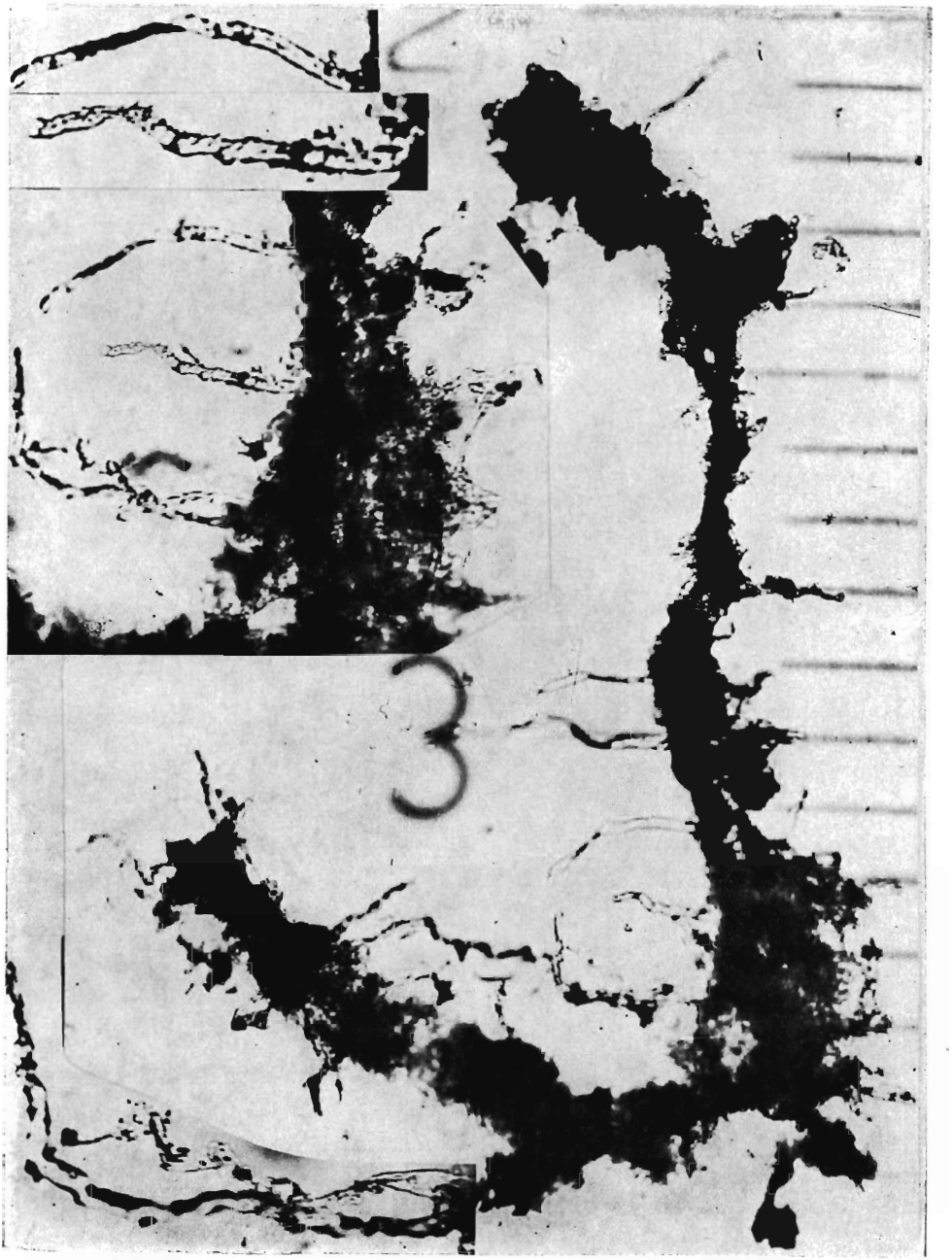


15 specimens of various plants. In the upper row cylindrical forms with and without branching (*Musciphyton* gen. nov.). One can estimate their size in the first row with a scale of 1 mm. In the lower row are specimens of *Hepaticaephyton* gen. nov., the highest being 8 mm, and the smallest 1.5 mm. *Phot. P. Greguss*



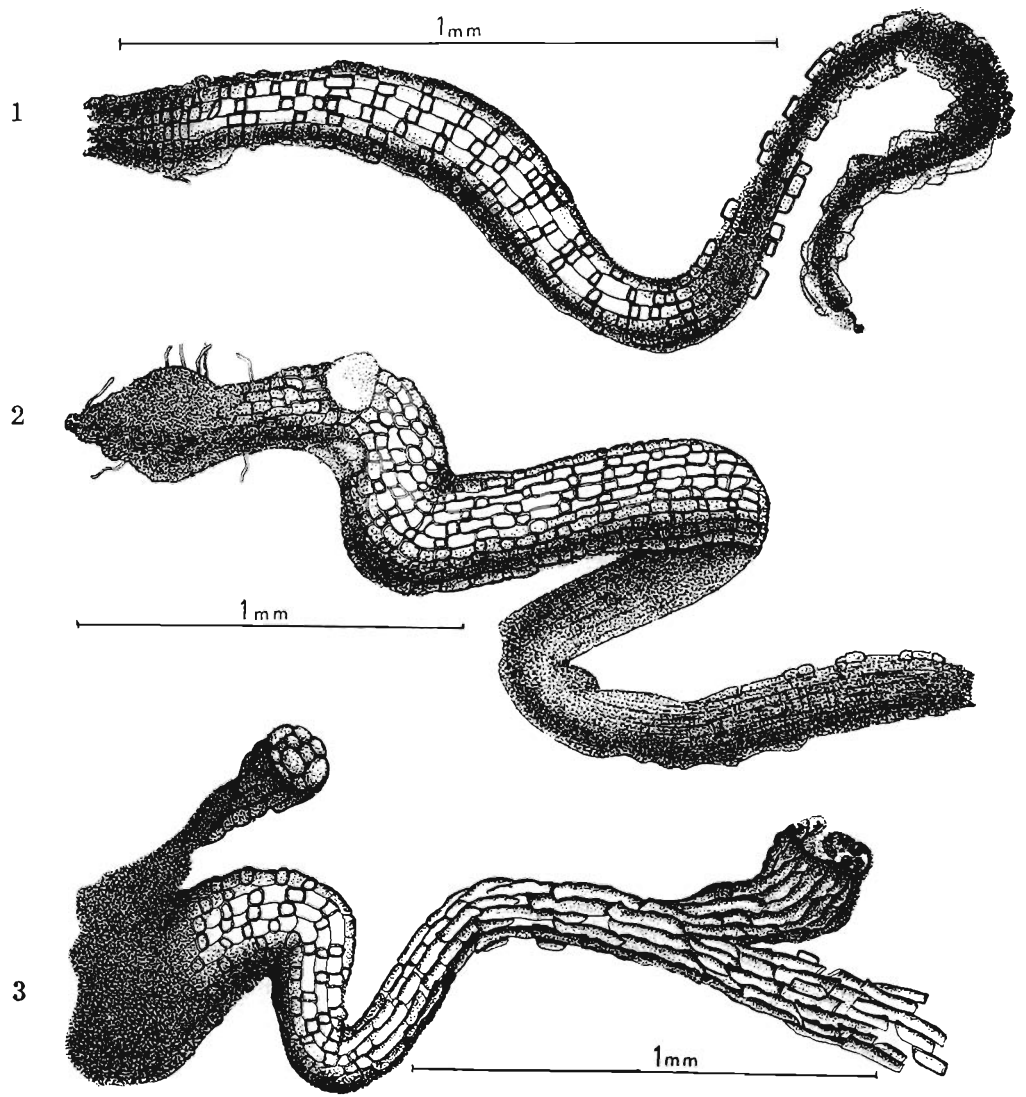
A plant with monopodial branching: cylindrical shoot arises from the stock of various thickness. Height approx. 2 mm. The body is covered with thick-walled rectangular cells. The apex of the rhizome has a vegetative cone (upper middle of the plate). Root hairs arise from the stock. A conductive strand is in the middle of the thin stem.

Phot. P. Greguss



A plant with dichotomous branching. From the stem a lobe arises with multicellular hairs on its end. Height 1.5 mm.

Phot. P. Greguss



Camera lucida drawings: 1. *Musciphyton kozlowskii* Greg. sp. nov., 2. *Musciphyton vistulense* Greg. sp. nov., 3. *Musciphyton ramosum* Greg. sp. nov. *Phot. P. Greguss*