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Freshwater Algae from a Lake in Proximity of the Novolazerevskaya Station, Antarctic

Sladkovodní řasy z jezera u stanice Novolazerevská v Antarktidě

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Abstract — The authors describe some material of freshwater algae which produce a large quantity of biomass in an antarctic lake under extremely cold temperature conditions (0—5° C). This nameless lake is situated in the Schirmacher Oasis (70°45'S, 11°43'E) and is covered with a thick ice-layer. The most abundant species (*Phormidium frigidum*, *Oscillatoria simplicissima* var. *antarctica* and *Cosmarium laeve* f. *majus*) are known mainly from the south circumpolar areas. Their morphological variability was studied in detail. The characteristics of the locality and some important ecological data are included.

Dr. Antonín Mrkos (Praha) submitted us some interesting material of freshwater algae he had collected in the antarctic summer season during the years 1962—63 from a lake near the Soviet Station „Novolazerevskaya" in Antarctic. The few algal species growing there produce large quantities of biomass. We describe this material and include a short characterization of the locality.[1])

The locality and ecological data

The material was collected from a nameless lake (70°45' S, 11°43' E) in a glacier bed on the northern margin of the Antarctic continent in Schirmacher Oasis, where the Soviet Antarctic Station „Novolazerevskaya" is situated. The lake is more or less circular in outline and has several bays, which run out in dry river-beds of several streams, flowing periodically from the glacier south of the lake. The area of the lake is about 1 km^2. In warmer years the water of the glacial streams raises the water surface of the lake and even doubles its area at times. Granitoides make up the substrate of the lake. The shores are flat and slope down slowly to the bottom; they are stony but large deposits of gravel and sandy clay are to be found in the environment. The ground is covered with boulders and stony scraps of various sizes. The depth of the lake was found to reach 8 m.

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[1]) We are very much indebted to Dr. Mrkos for the material placed at our disposal, as well as for the valuable information concerning the locality. Our thanks are also due to Dr. Petr Marvan (Brno) for the determination of the diatoms.

The lake is supplied with melt-water from the surrounding glaciers. The water is fresh, with a low content of mineral salts, pure, muddyless and transparent to the bottom. Its maximum temperature is +5 °C. In summer the lake is usually covered with snow-free ice, 2 to 3 m thick. The ice is relatively transparent and the quantity of light, sufficient for the development of the algae, penetrates as far as the bottom. Sun radiation may cause a complete melting of the ice-cover in warm years (once in three years on the average). The ice-cover does not melt in cold years (e.g. during 1961—1962 season) and open water may not appear during the whole summer season.

At 3—5 m depth there develops along the whole shore of the lake interesting communities of fresh water algae in leaf-shaped forms on areas of some dm^2 above the bottom. These strata of algae are in some places of a brownish colour due to the great content of ferric hydroxide. The algae produce a larger quantity of O_2 than can be dissolved in water, and the oxygen is present within the strata in the form of bubbles. The streaming of water and the oxygen bubbles cause the leaf-shaped strata of algae to get loose and rise to the higher water layers. There they freeze on to the ice-cover and ascend to the surface at a later time (the strong evaporation of the ice plays an important role in this process). Clusters of the algae often protrude in fan-shaped forms from the ice-cover and form a characteristic belt along the shore of the lake above the zone of the algal bottom-vegetation (Tab. XI, fig. 3—4).

Composition of the algal communities

In the algal strata described, blue-green algae (*Cyanophyta*) and desmids (*Desmidiales*) predominate. The main component is the blue-green alga *Phormidium frigidum* F. E. Fritsch, which influences the shape of the whole stratum. It forms large flat colonies with fine twisted trichomes, enveloped by strong colourless mucilagineous sheaths. In this substrate there grow also other species of algae.

These algae can be divided into two groups:
(1) Species helping to form the basic leaf-shaped pattern of the stratum, but occurring less abundantly. This category includes two blue-green algae: *Oscillatoria simplicissima* var. *antarctica* F. E. Fritsch and larger colonies of the species ? *Nostoc punctiforme* (Kütz.) Hariot.
(2) Species living freely in the mucilage or among the colonies of the three species mentioned above. It is particularly the desmid *Cosmarium laeve* f. *majus* Borge belonging to the dominants of the community beside *Phormidium frigidum* (though this is not exactly the organism forming the stratum). Small, several-celled colonies of the mentioned species of ? *Nostoc*, the rarely occurring chlorococcal alga *Scenedesmus armatus* Chod. and some small species of diatoms can also be placed here. Among the animals an undetermined rotifer species (*Rotatoria*) was rarely observed.

The list of all the algal species observed is presented, as well as their percentage occurrence in the community (determined by means of the six-grade scale, in which M represents the mass development and the numbers 5 to 1 different percentages: 80, 60, 40, and 20%, and the solitary occurrence in unit volume of the sample):

Phormidium frigidum F. E. Fritsch	M
Cosmarium laeve f. *majus* Borge	4—5
? *Nostoc punctiforme* (Kütz.) Hariot	2
Oscillatoria simplicissima var. *antarctica* F. E. Fritsch	2

Scenedesmus armatus CHOD.	1
Netrium oblongum (DE-BARY) LÜTK.	1
Achnanthes kryophila PETERS.	1
Navicula perpusilla GRUN.	1
Pinnularia borealis EHRENB.	1
Stauroneis anceps EHRENB.	1

Phytogeographical remarks

Two of the three determined species of blue-green algae (one of them dominant) were described from the Antarctic region, i.e. *Phormidium frigidum* and *Oscillatoria simplicissima* var. *antarctica*. Even though the first finding places of these algae are rather distant from our locality, the occurrence of the species in those places is not at all surprising.

Noteworthy is the mass production of the desmid *Cosmarium laeve* f. *majus*. This alga was known up to the present time from South Patagonia (BORGE 1901) only, where it occurred (probably very seldom) in several localities; no special data on its distribution and ecology were mentioned by the author. Our locality is also situated south of 50° S and even if both localities (Schirmacher Oasis and South Patagonia) are geographically rather distant and from the ecological view-point different, yet there is a conformity between them. Of course, it is necessary to study the geographical distribution of this species more intensely in future.

The third species of the blue-green algae, ? *Nostoc punctiforme* has not been elucidated until now. The material collected only once without reproduction stages, is insufficient for exact determination and it is possible that the species is a special type of a blue-green alga, characteristic of the described extreme biotope.

The other species of algae occurred only very rarely in our material. They are mostly very widely distributed species, often cosmopolites; in spite of this fact their occurrence in the described biotope was unexpected. They seem to have been brought to the locality. Sea birds (skua) play probably an important role in the distribution of all the algae found there. They come to the lake from the sea coast and dive in ice-free places or in the open holes in the ice-cover.

Description of the dominant species

? *Nostoc punctiforme* (KÜTZ.) HARIOT J. botanique 1891 : 31, 1891.

Fig. 1 : 3; Tab. XII, fig. 5 : 1—6.

Colonies globose or somewhat elongated, placed in firm, colourless and distinctly limited gelatinous sheaths; younger colonies may be slightly diffluent on the margin. Cells more or less spherical, very densely conglomerated, sometimes arranged in short filaments, with a light blue-green homogeneous content and a slightly distinct chromatoplasma. Dimensions: cells 2.6—5.4 μm in diam., colonies 35—500 μm in diam. Reproduction: cells by division, colonies by fragmentation into daughter colonies, sometimes into small few-celled groups only.

With regard to its habit the alga very strikingly resembles the initial stages of *Nostoc punctiforme*, particularly by the shape of young elongated colonies, the conglomeration of cells and their arrangement in the short chain-like filaments. But we have never observed heterocysts or spores which are the generic features. As the material was studied from one sample and we were able to study it in a fixed and desiccated state only, it was impossible to get

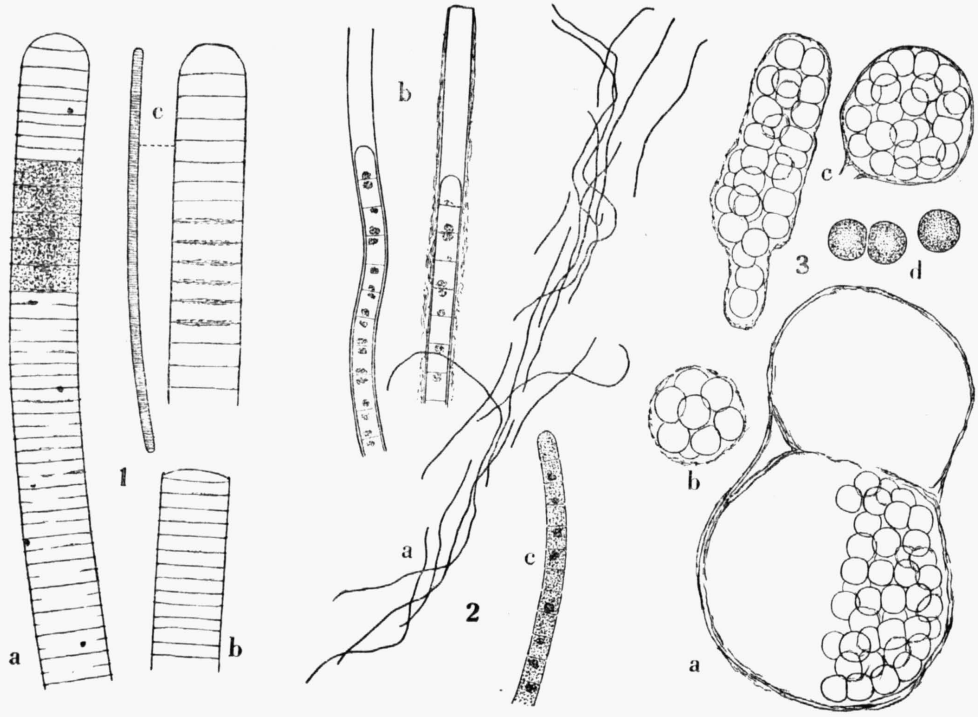

Fig. 1. — 1 — *Oscillatoria simplicissima* Gom. var. *antarctica* F. E. Fritsch: a — part of the trichome, b — part of trichome after hormogonium separation, c — growing hormogonium and a detail of its end; 2 — *Phormidium frigidum* F. E. Fritsch: a — habitus of a part of thallus, b — detail of filament ends, c — detail of trichom end; 3 — ? *Nostoc punctiforme* (Kütz.) Hakiot: a — an older colony, b and c — younger colonies. d — detail of cells.

a clear idea whether this was not the question of an unsteady or temporary modification („morpha"). *Nostoc punctiforme* is a very variable species; Geitler (1932) assumes that it includes more species which can be distinguished only on the basis of a detailed comparative study.

Our alga recalled also from other blue-green algae some species from the order *Pleurocapsales*. Yet we have never observed another type of reproduction than a simple division of cells.

Oscillatoria simplicissima Gom. var. *antarctica* F. E. Fritsch Nat. Antarct. Exped. 6 : 33, 1912.

Fig. 1 : 1; Tab. XII, fig. 5 : 7—8.

Trichomes slightly contorted till straight, along the whole length equally broad, not narrowed to the ends, not constricted at the cross walls. The apical cell widely rounded lacking a thickened outer membrane or possessing a slightly thickened one. After fragmentation into hormogonia the ends of the trichomes are more or less cut. Cells short, 2—6times shorter than broad. The cell content is fine but distinctly granulated, from light grey-blue to greenish; the dark brown granula are dispersed in the plasma. The distinct granulation is generally not on the transverse walls; sometimes flat bodies, resembling a thickened cross wall, are found. Dimensions: breadth of filaments = 10.5—11.2 μm. Reproduction: by hormogonia.

The alga occurred in strata of *Phormidium frigidum* in a small quantity, usually only in solitary trichomes, and only rarely formed little colonies. F. E. FRITSCH states in the original description that a considerable amount of necroid cells occur in the trichomes. In our material necroid cells were also present, but not in a high number. It is evident that the quantity of these cells depends on the environmental conditions and it is impossible to consider it as a taxonomical feature. Noteworthy is the relatively little variability of the width of the trichomes. In our material the trichomes were somewhat broader than those mentioned by FRITSCH. As to the other features, there were no considerable differences in comparison with the original description.

O. simplicissima GOM., which seemed to be widely distributed over the south circumpolar areas, was determined also by HIRANO (1959) in the material from East Ongul Island (width of filaments = about 8 μm). From the morphological point of view, this alga also resembles *Oscillatoria fracta* CARLSON, described from the snow fields of Antarctica. It differs from the latter species only by larger dimensions (trichomes of *O. fracta* are 6—7 μm broad), by the absence of transveral lines of granula in the cells and by a smaller fragmentation of filaments. All these features are too variable in the genus *Oscillatoria* and the identity of *O. fracta* with *O. simplicissima* is very probable.

Phormidium frigidum F. E. FRITSCH Nat. Antarct. Exped. 6 : 31, 1912.

Fig. 1 : 2.

Thallus forms extensive flat strata some decimeters in diameter. Filaments with a rich production of mucilage (originating from the membrane) are situated more or less parallelly and they are straight or slightly curved or intertwisted. Sheaths colourless, on the margins very diffluent and gelatinized. Trichomes along the whole length equally broad, ended by a rounded cell, with a indistinctly visible constriction on the transverse walls. Cell content blue-greenish, without granulation on the cross walls. The transverse walls are indistinctly visible. In the majority of the cells solitary, indistinct and relatively large bodies there are near the cross walls. Dimensions: trichomes 0,6—1,0 μm broad. Reproduction: by hormogonia.

According to the mass occurrence it can be assumed that this species is well adapted for the antarctic milieu from where it was described. Its records from central Europe (High Tatra Mountains) are very problematic.

In contradiction to FRITSCH's original description, the trichomes in our material are narrower and the constriction on the cross walls less distinct. These differences do not deviate, however, our material from the range of its variability. We do not consider, therefore, the studied alga as a different species, or as an infraspecific taxon of *Phormidium frigidum*.

Cosmarium laeve RABENH. var. *laeve* f. *majus* BORGE in W. et G. S. WEST Monogr. Desm. 3 : 101, 1908.

Fig. 2 : 1—7; Tab. XII, fig. 6 : 1—12.

Cells in outline nearly elliptic or elongated-octogonal, mostly somewhat asymetrical or irregular. The cell margins either equally curved or roundly angular; in this case their sides are not undulated or only slightly. On one semicell there are mostly 8 conspicuous waves. The lower parts of the sides at the base are converging or diverging towards the apex or they are parallel. The apex is mostly slightly retused; its breadth rather varies. The apical membrane is usually slightly thickened. In the vertical view the cells are elliptic, without lateral tumidities. Dimensions: length of the cells = 32—40 (43) μm, breadth of the cells = 24—30 (31) μm, breadth of the isthmus = 8—12 μm, ratio between breadth and length (1.22) 1,25—1.42 (1.50), thickness of the cells 15—21 μm.

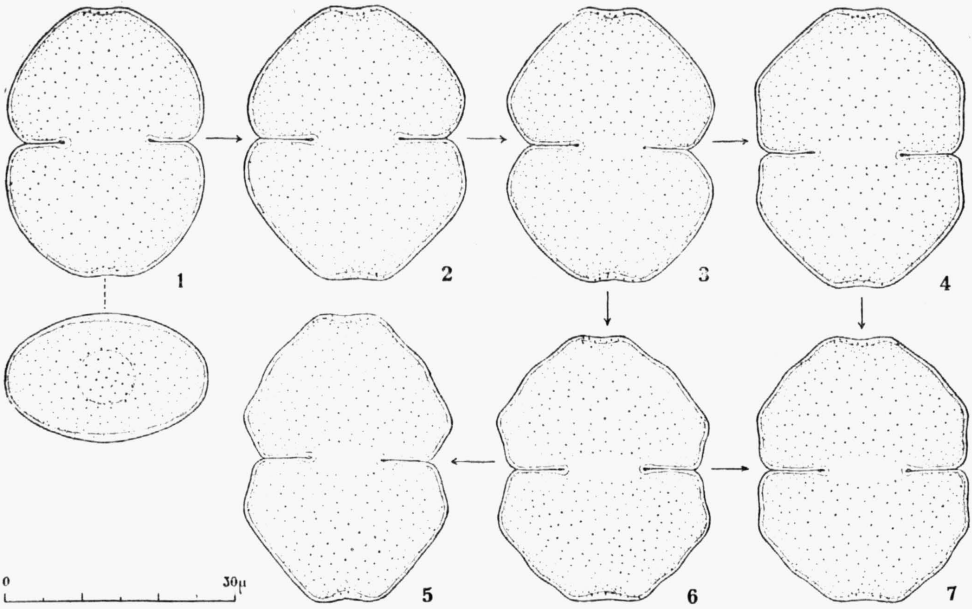

Fig. 2. — *Cosmarium laeve* RABENH. var. *laeve* f. *majus* BORGE, morphae.

The finding of this alga in Antarctica is interesting for two reasons. It completes BORGE's (1901) primary publication about the alga from South Patagonia; the mass occurrence, moreover, enables the study of its morphological variability.

In so far as morphology is concerned, the alga resembles in all dstails the species *Cosmarium laeve* RABENH. 1856, which is commonly distributed in all European waters and is probably of a cosmopolitan occurrence. There does not exist another shape occurring in the range of a typical form of *C. leave* — and some varieties, esp. var. *octangularis* (WILLE) W. et G. S. WEST 1908 including — which would not be found in the material from Antarctica. It differs from *C. laeve* f. *laeve* in its dimensions only, the size of which is approximately one third and more. So, e.g., the length at f. *laeve* seldom exceeds 25 μm and only exceptionally 30 μm (W. et G. S. WEST 1908, p. 100 describe the maximal length as 34 μm), while we have found the mean length at f. *majus* to be 36,33 $\pm$ 3 . 1.18 μm (300 specimens have been measured) and the maximal length 43 μm. This only differenciating feature seems to be steady enough and we can consider the alga as an independent infraspecific taxon, pro forma. BORGE (1901) presents the dimensions of his finding from South Patagonia as 32—36 $\times$ 23—26 μm.

We have often found specimens in the material, which were very different from the morphological point of view, but the individual modifications were always connected by a continuous line of transitional forms. It was impossible to find any limits between them. The wide range of the morphological variability of the alga is documented by drawings and photographs (Fig. 2; Tab. XII,

fig. 6). It was impossible to draw all the existing shapes with all the transitions and we are only demonstrating the most characteristic ones.

Some modifications differed from one another to such a degree that they could be considered as independent species and varieties (according to the present taxonomic criteria), if they were found isolated. With regard to the extreme conditions under which the alga grew and reached its mass development, it is most probable that it is only one taxon and not a mixture of different species and varieties. That also follows from the improbability that among few algal species there would arise a simultaneous mass development of several very relative species from the genus *Cosmarium* with continuously and strongly changing morphology. It was possible to put the distribution of length, breadth and the ratio of length to breadth in very regular distribution curve without any indication of two or more apices. This also proves the homogenity of the material.

The described population represents a new proof of the fact that in the order *Desmidiales* as well as in other groups of algae, the natural taxa (species or infraspecific taxa) include a ± large range of variable unsteady modifications ("morphae"). They change their morphological shape in the course of the subsequent generations owing to the internal or external conditions. It is quite useless and superfluous to describe such unsteady modifications in the algal taxonomy as independent taxa (forms, varieties, species, exceptionally also genera). Before the publication of a new taxon it is necessary to ascertain, if this is not the question of an unsteady modification of the continuous line of the large variable range of "morphae" of a well-known taxon.

In the samples of the algal material, we have mostly single, randomly found modifications from the whole range of variability at our disposal and it was usually not easy to prove their mutual continuity. This proved by the population described, where the whole large variability of one taxon is known.

With regard to the mass development of this alga in a biotope with the temperature exceeding slightly 0° C, we can conclude that it is a psychrophylic alga. Such types occur very seldom in the order *Desmidiales*. But this single occurrence does not allow us to speak with certainty about its ecological requirements.

As to the geographical distribution (south circumpolar areas), it is possible that individual „morphae" resemble some other species and are found also within other localities and published under different names.

Conclusion

1. A community of freshwater algae from an antarctic lake, covered with a thick layer of ice, is described. The algae developed in the form of leaf-shaped strata, mostly in depths of 3—5 m below the surface. In this community 3 species of blue-green algae, esp. *Phormidium frigidum* E. F. Fritsch dominated (which caused the characteristic habit of the algal stratum) and the desmid *Cosmarium laeve* f. *majus* Borge. These species produced a large quantity of biomass in the extreme locality mentioned.

2. The morphological variability of the four mostly frequently occurring species is described and comments on their geographical distribution are included.

Souhrn

V antarktických sladkovodních jezerech se vyvíjejí během letního jihopolárního období zajímavá a vyhraněná společenstva řas, často pod silnou vrstvou ledu (až několik m). K jejich rozvoji stačí světlo procházející ledem a teplota často jen několik °C nad nulou.

V Schirmacherově oase v Antarktidě (70°45' j. z. š. a 11°43' v. z. d.) se vyskytuje několik podobných, nepojmenovaných vodních nádrží. V tomto článku jsme zpracovali materiál, který zde sbíral v sezóně 1962/1963 dr. Antonín M r k o s. Převládajícími druhy byly sinice (*Phormidium frigidum, Oscillatoria simplicissima* var. *antarctica*) a krásivka *Cosmarium laeve* f. *majus*, vesměs známé pouze z jižních cirkumpolárních oblastí. V článku je uveden popis materiálu dominantních druhů a jejich morfologické variability na této vyhraněné a isolované lokalitě.

Uvedené druhy tvoří rozsáhlá, makroskopická, listovitá ložiska, vegetující zprvu v povlacích na kamenitém dně; ta se později odtrhávají, přimrzávají k ledovému pokryvu a dostávají se až nad jeho povrch (jednak v puklinách a v děrách v ledu, jednak intensivním odparem na povrchu ledové pokrývky a přimrzáním jejích dalších, spodních vrstev — Fig. 3). Článek je doplněn charakteristikou lokality a hlavními ekologickými daty.

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E x p l a n a t i o n s o f t h e p l a t e s:

T a b. XI:

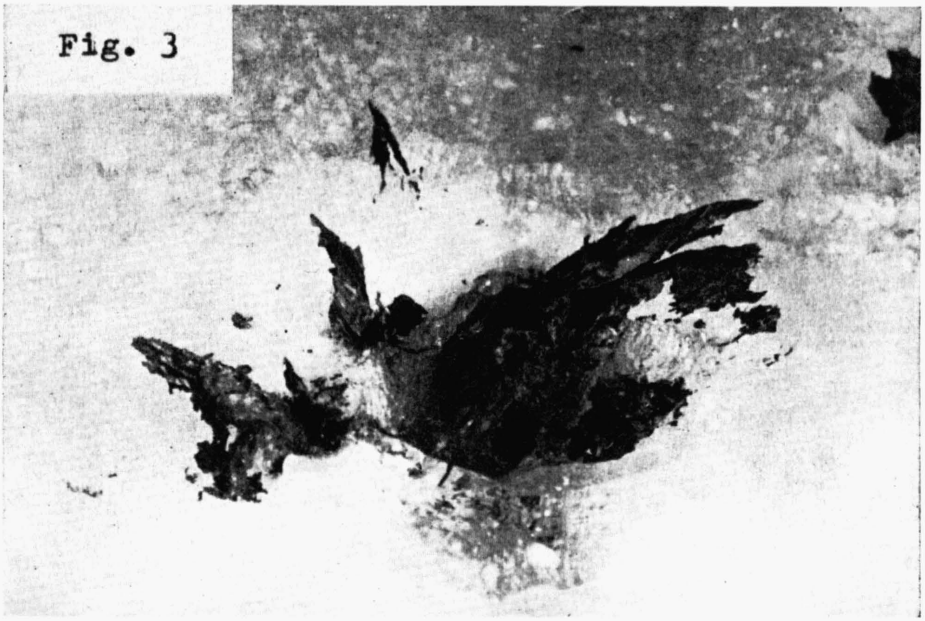
Fig. 3 — Algal strata, getting detached from the bottom, frozen sometimes secondarily in the ice-cover of the lake (photo Dr. A. M r k o s).

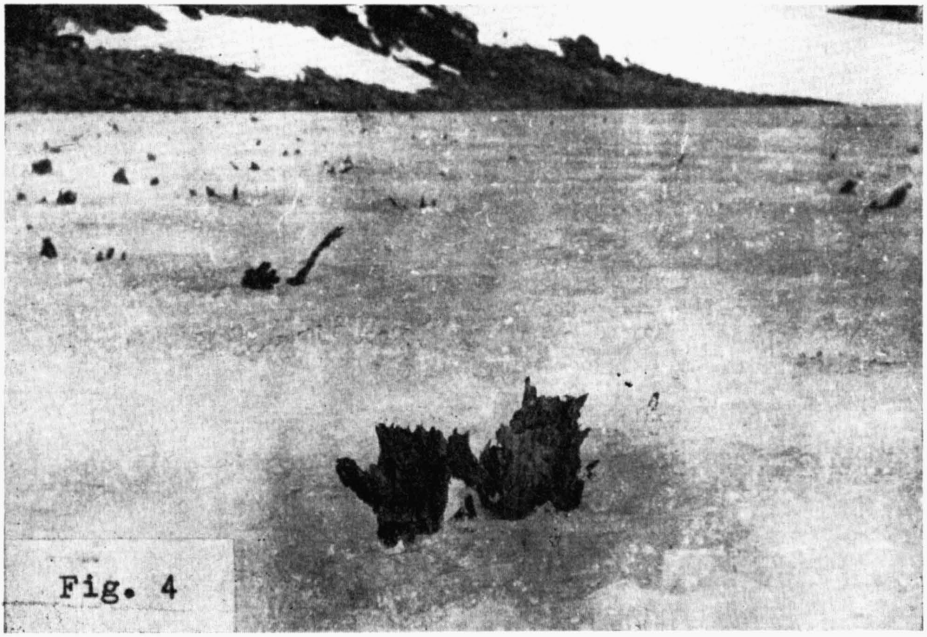
Fig. 4 — Algal strata, frozen on the surface of the ice-cover, form a characteristic belt along the shore of the lake (photo Dr. A. M r k o s).

T a b. XII:

Fig. 5 — 1 to 6 — ? *Nostoc punctiforme* (KÜTZ.) HARIOT, colonies of different age; 7 to 8 — *Oscillatoria simplicissima* var. *antarctica* F. E. FRITSCH; (photo Dr. J. R ů ž i č k a).

Fig. 6 — *Cosmarium laeve* var. *laeve* f. *majus* BORGE: 1 to 11 — e fronte, 12 — e vertice; (photo Dr. J. R ů ž i č k a).





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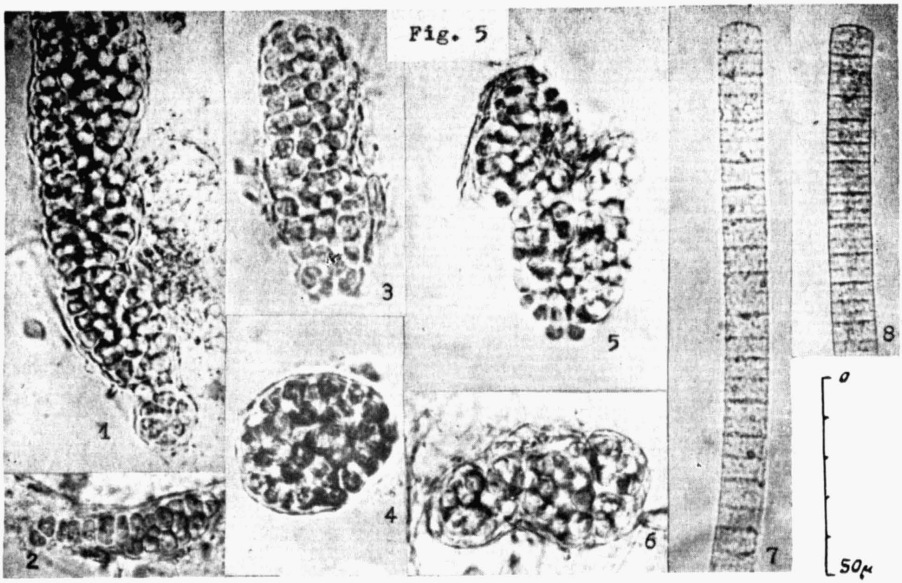

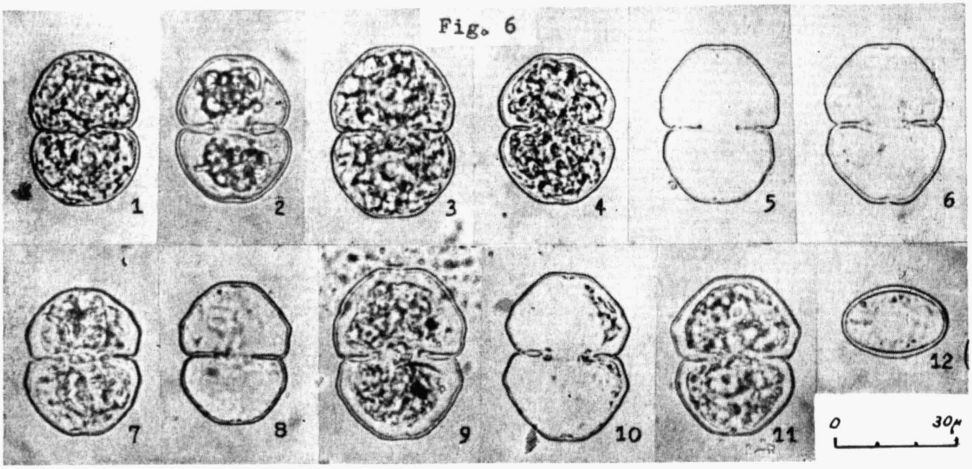

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