Algae on Surtsey in 1969—1970

By
G. H. SCHWABE and K. BEHRE†
Max-Planck-Institut für Limnologie, D-232 Plön.

In the ecogenesis of this volcanic island two biomes can clearly be distinguished:

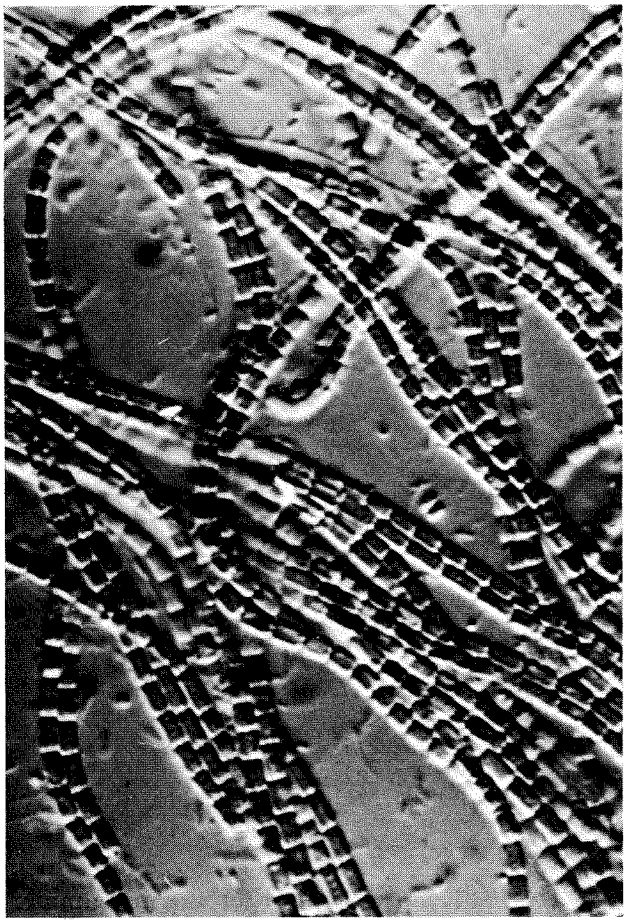
1. The marine litoral and sublitorial,
2. The proper surface of the island as a terrestrial region. (Natural inland waters do no longer exist there after two shore-pools have been filled up with wind-shifted tephroite (1967 and 1969) and a rock-pool was destroyed by breakers.)

In both of the biomes the early stages of ecogenesis are most clearly marked by cryptogams. The marine litoral and sublitoral, as far as the substrata are fixed, has been covered for several years (S. Jónsson 1970, M. S. Doty 1967) by a rapidly growing vegetation which is rich in species. These populations of algae cover wide continuous areas. In the splashing zone on surface lava early deposits of algae have developed, which no doubt belong to the marine biome.

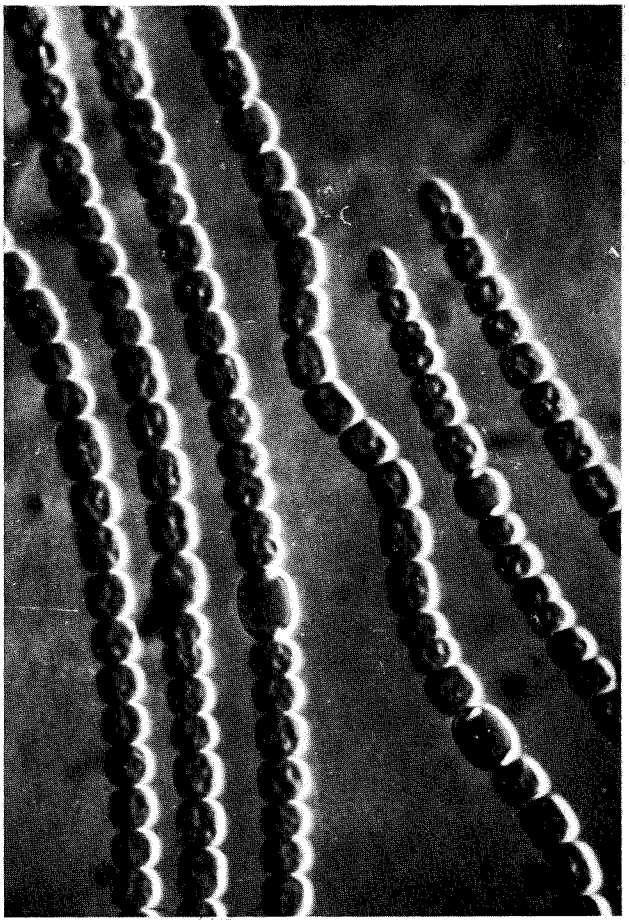
In contrast to this, the colonization of the terrestrial biome begins in small restricted "oases", remaining limited to these at least until summer 1969. Only later a diffuse colonization can be found which, however, also in summer 1971 is yet restricted to small favourable biotopes. — The striking difference between these two biomes is due to several factors:

1. Below the sea-level and on lava rocks within the reach of breakers the young volcanic material only serves as a substratum for the young vegeation, so that it is only important from a mechanical point of view. The chemical character of the erupted matter does not decisively influence its colonization, especially as a continued change of water dilutes any toxical factors below the tidal zone in a short time. The biotic metabolism there is almost exclusively determined by salt-water. In contrast to this the autotrophic beings in the terrestrial area also with regard to the physiology of their maintenance depend upon the substratum, i. e. they depend on nutritive matter available there and are exposed to its restraining and toxical factors. Atmospheric weathering and tephroite shifted by winds apparently delay considerably the elimination of poisons from the substratum. These problems have not yet been investigated in details.
2. Above the high-water mark and the splashing zone (on surface lava) the development of the vegetation is particularly restricted by a periodical shortage of water, whilst below this level there is no such restriction.
3. The shifting of dry tephroite by wind, which is gradually diminishing, but up to summer 1971 was clearly recognisable, checks in several respects any development of vegetation (partial or complete covering by tephroite, mechanical damages).
4. In the marine area the natural flow of the organisms (perennial germs, propagational organs, cells, vital fragments) which may develop on new substratum, is comparatively much greater than in the terrestrial area, which is ecologically isolated from similar biotopes. This difference is, however, of minor importance in comparison with the above-mentioned factors. The majority of organisms arriving on the surface of the island will be frustrated by the unfavourable ecological conditions there. This is clearly recognizable by a comparison between the areas of colonization (particularly of mosses) and their development between 1968 and 1971.

Due to these conditions the vegetation recognizable with the naked eye (apart from some Phanerogames, which are not discussed here) seems to be restricted — until summer 1969 — to the next surroundings of steam-crevices. This vegetation consists of scarce turfs of mosses and here and there populations of algae, which are just recognizable at favourable lighting as a



Schizothrix lardacea (13.9.69) S. 249/345/16



Anabaena variabilis (4.10.70) S. 327/304/34

greenish sheen on the surface of fine ash which is fasten through humidity. Numerous investigations of substrate samples from all regions of the island (unselective enrichment cultures with substrates from all parts of the island and microscopic controls) confirm that up to that time an active population of algae is restricted nearly without exceptions to these post-volcanic oases of the ecogenesis. But in these places the number of living species is extraordinarily great (in 1968 already more than 100 species). Just a few meters distance from these places either no algae at all or only single species are found in the raw cultures. It is very probable that these single findings have come out of the resting stages, which originate from the oases and were removed by wind, and more seldom by water.

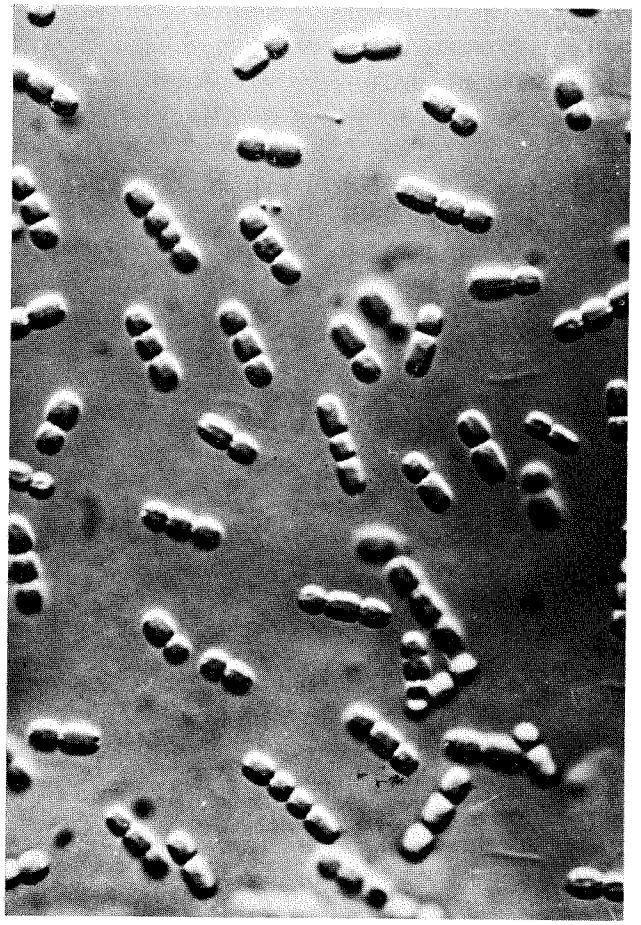
The hitherto existing results of the 1969 and 1970 investigations show above all two processes:

1. A quick increase in number of species, especially in the oases,
2. The beginning of active population in places which are outside of the influence of steam and, moreover, are microclimatically favoured.

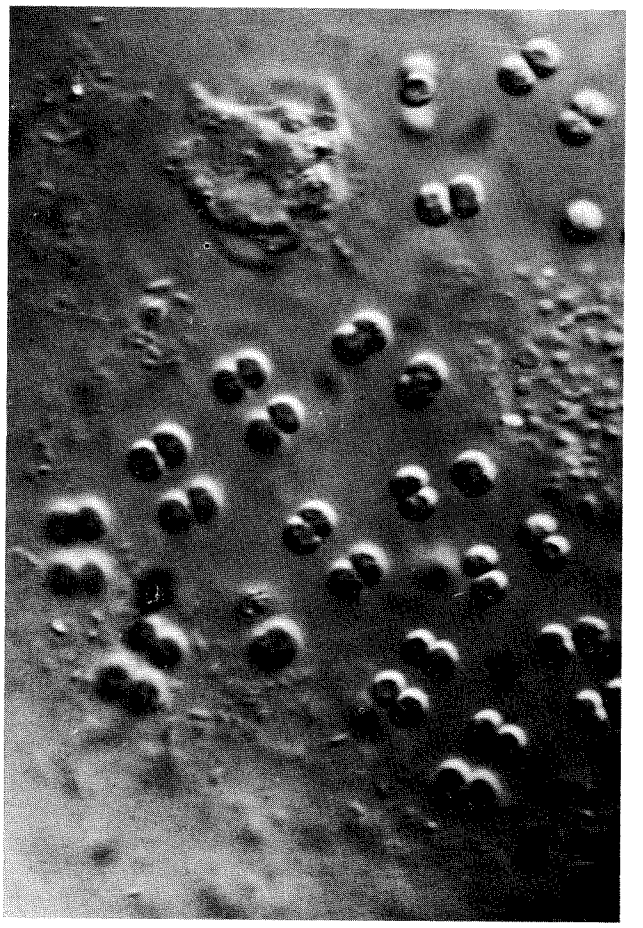
As the taxonomic analysis of the extensive material is not completed, no exact data can be given. In 1970 the active population of the island by algae (i. e. the quantity of algae developing and increasing there) will surely turn out manifold in number of species compared to what it was in 1968.

This microflora is largely identical with the algae-flora of Icelandic raw soils, but represents a selection of small and smallest forms. Such an assortment leads to the assumption that it is mainly the atmosphere (transportation by wind) which carries the populating species to Surtsey; this hypothesis is supported by various observations:

1. Substrata exposed on the steeple of Landakot-church in Reykjavík (summer 1970) hitherto contained a. o. at least 3 species which frequently appear as pioneers at Surtsey.
2. Those oases most exposed to wind (the upper by-craters in Surtur I and especially Strompur) show an extremely high number of species. (These places are relatively seldom visited by visitors to Surtsey, so that just here an anthropogene importation is hardly probable.)



Phormidium mucicola (2.12.70) S. 311/418/9



Aphanocapsa grevillei (12.9.70) S. 299/401/11

The strong enrichment in algal flora in the last years is probably less due to the increase in number of immigrants, but to increasing favourable conditions for colonization offered by the substrates on Surtsey through transformation, binding and weathering. Through alteration by wind and local accumulations of fine fractions of ash, which is especially the case in the unevenness and deepenings of the lava planes, the storing of rain water (protected against quick evaporation) is favoured in certain places. Here, the development of moss turfs is directly striking. Apart from Rhacomitrium, which — as was reported from Iceland — seems to prevent any development of algae, all moss locations on Surtsey were populated by soil algae (especially Anabaena variabilis is very frequently represented).

The diffuse expansion (phase of the diffuse ecogenesis), which has been striking since summer 1970, but was already recognizable during investigation of the algae in summer 1969, is most clearly shown through distribution of the moss turfs whose single parts only seldom surpass some few square centimeters. Until summer 1971 such turfs have only been found in places which are well supplied with water (clefts, cracks and deepenings in the lava where fine ash accumulated or excavations with sufficient light, which are protected against air movements). On the other hand, however, areas exposed to full sun radiation and wind and as well to the south are avoided. The spreading of algae does not confirm these findings anymore with the applied methods, because obviously cells of algae capable of living have already been spread all over the island by wind, and thus practically all superficial substrate samples give positive culture results. But the surroundings of steam exits still turn out to be richest in regard to number of species and to population density.

But on the other hand just those oases which developed at lava cracks are exposed to characteristic damages and back-strokes. The steam cracks are formed and deepened through proceeding cooling of the lava (contraction cracks). Therefore the development of vegetation is favoured over years as long as under these conditions a relatively continuous supply of water is secured through condensation of steam. Although at times an intensified output of steam enhances the local filling and binding of drifting ash and along with it buries the cryptogame

vegetation, but generally the mosses grow over such overlaps and at the same time the movable algae forms seem to overcome actively such layers (especially Cyanophytes and Diatoms). Just in one special case could we observe the almost complete destruction of a steam biotop rich in species and extended over some square decimeters (middle by-crater around Surtur I, between 1968 and 1970, "chair"), owing to drift. In general the oases areas are enlarged through intensified output of steam.

If on the contrary — e. g. due to less rain falls as in early summer 1971 — the supply of water to the cracked regions is diminishing, the temperatures of the outcoming air-steam-mixture rise, at the reduced percentage of steam, to such an extent that there will be no more condensation and the surface temperatures may rise above the boiling point. In summer 1970 the area most exuberant in mosses in Surtur II (more than 100 m^2) had been encircled with a hemp cord and marked. One year later the whole visible vegetation was destroyed and the cord was burnt at several spots. After an early summer poor in rain fall the only obvious reason for this backstroke, which is regionally limited but characteristic for steam-cracks, seems to be in reduced supply of water at continuous deepening of the contraction cracks, which led consequently to a drying-up and over-heating of the populated areas.

In the same period, however, further diffuse colonization took place in post-volcanic non-active regions, especially on the lava-planes. A considerable quantity of the "seed-corn" which developed there, very likely seems to orginate from the vegetations of the pioneer oases which are meanwhile again partially destroyed. Thus, the ecogenesis is a process going on discontinually in its single steps. And moreover, another proof seems to be given by the population dynamics under the influence of new immigrants.

In August 1971 Dr. Karl Behre, Bremen, gives the following report on his observations hitherto made for the years 1969 and 1970 (soil algae, without Cyanophytes):

"The investigations started in 1968 were continued on broader basis. Whereas, there were only 11 samples in 1968 which have been collected almost exclusively from the craters Surtur I and Surtur II, while 31 samples in 1969 and 47 samples in 1970 collected from the different parts on the island, were also investigated.

Soon after in 1968 the typical soil forms of the Diatoms had been strongly represented, this happened with other algae groups as well or they became predominating where as before they were represented by smaller numbers.

The Heterocontae increased from two forms in 1968 to almost a dozen in 1970, among them were several species of *Heterothrix (H. exilis,* one of the most frequent soil algae, *H. tribonematoidea, H. montana).* In 1970 *Tribonema* joined with *T. elegans* and *T. minus.* The presumably cosmopolitan soil algae *Monodus subterranca* now appeared in 14 samples. One moss sample contained *Characiopsis minor* in all three investigated cultures, which up to now had not been reported as soil algae, but lived in large quantities on the humid mosses.

The Eugleninae kept their low initial frequency, *Euglena mutabilis* was found every year in one or two samples, besides a second *Euglena* species and some species of Petalomonas and *Notosolenos* were very sporadic. Specially in the last years few individuals of certain colourless flagellates, primarely *Rhynchomonas nasuta* and several *Cercobodo*-species, were also repeatedly found.

In the following two years almost 20 forms of *Chlamydomonas* were found, which already in 1968 showed a striking frequency of 8 species; about one dozen could be put near to known species (these were: *C. moewusii, C. moewusii* v. *major, C. oviformis, C. debaryana* v. *micropapillata, C. petasus, C. rotula, C. asymmetrica* v. gallica and v. minima, C. intermedia). The two species C. foraminata and C. pseudintermedia newly described for 1968, have also been well represented in the following time, in 6 samples in 1970. Now, the first Carteria appeared in few specimen.

Already in 1968 the Chlorococcales were represented by the soil alga *Chlorella.* Together with four different forms of the three species *C. vulgaris, C. saccharophila* and *C. minima* it belonged in 1969 to the predominating soil algae which were found in nearly every sample. 1970 showed a slight reduction, but *C. vulgaris* still appeared in 18 samples. — Since 1969 *Chlorococcum* and related genera appeared in a number of problematic forms which up to now could not be determined. — *Scenedesmus* appeared — especially with S. ecornis (in three samples) — for the first time in 1969, whereas in 1970 the most frequent form (in four samples) was approximately correspondant to *S. chlorelloides.* Further, *S. acutiformis* and *S. microspina* were found. — One sample frequently contained the soil alga *Dictyosphaerium minutum* which had rarely been found up to that time.

Meanwhile the filiform green algae, which were almost completely lacking at the beginning, have strongly developed. *Chlorhormidium flaccidum* with 6 samples in 1969 and 26 samples in 1970 can be regarded as the most frequent soil algae on the island. *Chlorhormidium pseudostichococcus* was represented with 7 samples in 1969 and with 4 samples in 1970. *Gloeotila protogenita,* found in Surtur I, however, decreased from 4 samples in 1968 to 2 samples in 1970, which — as must be admitted — this time were collected from different places on the island. *Stichococcus* minor and *S. bacillaris* s. ampl. increased from 1 (respectively 2) to 8 (3) samples with the particularity that they preferred isolated localities (outside of Surtur I and II).

Generally Desmidiaceae are not known as air algae. Nevertheless in 1969 *Closterium pusillum* and *Mesotaenium macrococcum* appeared in some samples. In 1970 an Actinotaenium joined, and *C .pusillum* was reported in 9 samples from 4 different localities on the island.

As the preparation of the diatoms for finer investigation could not yet be done, this group is only considered as far as the forms are recognisable in fresh state. — The 4 "soil algae par excellence" *Navicula atomus, N. mutica, Pinnularia borealis* and *Hantzschia amphioxys* had already been found in 1968 and are still there: the first 2 belonging to the most frequent algae, *Pinnularia borealis* from the beginning only in few samples, *Hantzschia amphioxys* ranging amongst the top group in 1968, but only found in few specimen in 1969 and then again contained in 11 samples in 1970. This fluctuation is surprising, but there is no possible doubt about it, as this alga can easily and surely be recognized with the dry system. It is further remarkable to see the strong development of *Nitzschia fonticola,* which was found in 1968 in one specimen in each of the two craters, and appeared in 1969 in 5 and in 1970 in 13 samples. *Pinnularia intermedia,* found in 4 samples from Surtur I in the year 1968, appeared in the fresh 1969 material only in the 5 cultures of one sample near the western shore of the island, and in 1970 in 7 samples it was spread over the whole island. During these 3 years *Navicula* cf. *dismutica* remained in the single samples, but these ones coming from completely different places on the island. During 1970 *Achnanthes coarctata* appeared in 3 samples from different places on the island. — As a whole the number of species of diatoms seems to have decreased a bit in 1969, but increased again in 1970.

In the last two years there were no more ecological differences between the craters Surtur I and II (different humidity), the algae were now equally distributed over these 2 — always still very rich — localities. But at the same time there appeared forms, from the most different places on the island, which up to now have not been observed in regard to the regularity in their distribution, so as to make any definite statements here."

The analysis of the "soil algae" in the last three years gave a. o. the surprising result of a relatively great number of rare or — up to that time — completely unknown species. These findings cannot satisfactorily be explained with a merely insufficient general knowledge of these groups. The relative frequency of some of such novices is a counter-argument to such an interpretation (besides other concomitant circumstances). So, at least for the present we can assume that under the local special conditions some species can develop, which somewhere else, i. e. in older "matured" biotopes, would not stand the competition they meet there and may even be able (for instance as sprinkles into other populations) to reach a stage of spreading where they can predominate in new territory still free of competition (in non-occupied niches) or even develop "pure populations". Without such assumptions, for example, the existence of two hitherto unknown Nostocaceae — both are distinctly thermophilic — can hardly be understood.

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