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Hypolithic Biocrust in the Larsemann Hills of East Antarctica: Spatial Patterns, Organic Matter Stabilization, Comparison with Endolithic Systems

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The survey conducted in the Larsemann Hills oasis of East Antarctica (69°24'S, 76°14'E) revealed that hypolithic and endolithic bio-abiotic systems occupy from 20 to 60% of the wet valleys floors and slopes area. As in many other parts of Antarctica a significant portion of organic matter in Larsemann Hills is produced in cryptic niches inside the fissure network of hard rocks or under the stone pavements on loose sediments. The dominant autotrophic components of such ecosystems are cyanobacteria and green algae, mainly in the form of biofilms. However moss dominated communities could form distinct patterns within hypolithic biocrust. The spatial distribution of various types of hypolithic biocrusts, its thickness, moisture content, carbon and nitrogen content/stocks, as well as C/N ratios were studied at a detailed scale at several key sites along the grid of 10x10 m with a step of 1 m (121 sampling points each). The data received are evident that microbial and cryptogamic photoautotrophs activity in hidden habitats under the stone pavements could lead to the substantial organic matter accumulation in extreme environment of East Antarctica - up to 5% of C and 0.4% of N. However the radiocarbon data indicate that in many cases the values of fraction modern (F14C) exceed "1" which means that organic matter in hypolithic biocrust is not preserved in a long-term period. This contrasts with 14C "ages" of endolithic systems on surrounding slopes of the valley exceeding 500 and sometimes 1000 yr BP. We found that once hypolithic organogenous material is buried under sand and gravel 2-5 cm deeper than common hypolithic biocrust it could preserve for a dramatically longer periods and have the 14C "age" up to 1100 yr BP. As evidenced by optical and scanning electron microscopy with EDX this old organogenous material of hypolithic origin still retains clear filamentous structure of cyanobacteria biofilm as well as remnants of EPS stabilized mainly by amorphous Si and Al compounds. Both "fresh" hypolithic organic carbon pool utilized by biogenic and abiogenic processes (e.g. erosion) and the older one, which is more stabilized through burial, are superimposed on the really old carbon pool with 14C "ages" exceeding 6000 yr BP. The latter starts from the depth of 8-10 cm and has a complex origin comprising relocated endolithic microfossils, lacustrine and other carbon. It resembles the dual carbon pool model of a common soil with fast pool in topsoil and slow one in subsoil. C/N ratios in modern hypolithic biocrust varied between 7 to 30 and δ13C between -24 to -30‰ both indicating differences in microbial and cryptogamic photoautotrophs contribution. δ13C for endolithic organogenous horizons vary normally in a more narrow range between -22 to -24‰ . Carbon dioxide emission (g C-CO_2/m2 per hour) altered between 0.008 from the surface of cyanobacteria dominated hypolithic biocrust to 0.023 from the moss dominated one. Understanding modern hypolithic and endolithic systems is of fundamental importance, since they are possibly the closest modern analogues of protosoils that existed before the vascular plants with root systems established.