Nelumbo *Vol 59(1), (105-109) 2019*
DOI : 10.20324/nelumbo/v59/2017/115982

ISSN (Print) : 0976-5069
ISSN (Online) : 2455-376X

Chroococcidiopsis, A Cryptoendolithic Cyanobacterium from Larsemann Hills, East Antarctica

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पूर्वी अंटार्कटिका के लारसेमन पर्वत से ज्ञात एक क्रिप्टोइंडोलिथिक सायनोजीवाणु : *क्रोकोक्सीडियोप्सिस*

सुदीप्त कुमार दास एवं देवेन्द्र सिंह

सारांश

क्रिप्टोइंडोलिथिक जीवाणु समुदाय अंटार्कटिका में एक महत्वपूर्ण सूक्ष्मपारितंत्र का प्रतिनिधित्व करते हैं। शैवाक, कवक एवं शैवाल इस जैवतंत्र के अभिन्न अंग हैं। प्रस्तुत अध्ययन में पूर्वी अंटार्कटिका के लारसेमन पर्वत की चट्टान से प्राप्त किये गये क्रिप्टोइंडोलिथिक सायनोजीवाणु *क्रोकोक्सीडियोप्सिस* का अभिलेखन किया गया है।

ABSTRACT

Cryptoendolithic microbial communities represent a significant microecosystem in Antarctica. Lichens, fungi and algae are the integral components of this biome. In the present communication a cryptoendolithic cyanobacterium, *Chroococcidiopsis* is reported from the bed rock of Larsemann Hills, East Antarctica.

Keywords: Antarctica, *Chroococcidiopsis,* cyanobacterium, Larsemann Hills

INTRODUCTION

Cyanobacteria are the extreme-tolerant microorganisms growing on every light-exposed niche in the harshest environment of Antarctica. They not only form slimy benthic bio-films in the aquatic habitats but also colonize on the soil and rock surfaces and sometimes refuge within the rocks, called as endoliths. This high degree of plasticity in the cyanobacterial life style is promoted by low amount of available substrata, extreme climatic conditions and the short period favorable for growth in Antarctica (Hawksworth, 2005). These microorganisms prefer the inside of rocks rather than their surfaces, because of the wide thermal fluctuation on the exposed surfaces leading to their sterility for microbes, while the stable nano-climatic conditions within the rock provide a much suitable ambience (Nienow & Friedmann, 1993; de los Rios & al., 2003). The endolithic colonization can be viewed as a stress avoidance strategy, where overlying mineral substrate provides efficient protection from lethal UV radiation, thermal buffering, protection from

Received: 16.01.2017 Accepted: 24.04.2017 Date of Publication: 31.07.2017

freeze-thaw events, physical stability and enhance moisture availability (Pointing & Belnap, 2012; Wierzchos & al., 2012).

Existence of microorganisms in rocks and their role in their biochemical weathering in Antarctica was first reported by Glazovskaya (1958). Friedmann and Ocampo-Friedmann (1976) suggested the term endoliths and categorized them into crypto-, chasmo- and euendoliths according to their colonization pattern in the rock interior, i.e. through fissures, structural cavities and drilled tunnels, respectively (Friedmann & Ocampo-Friedmann, 1976; Friedmann, 1982). In Antarctica, mostly two types of endolithic communities occur; chasmoendoliths (in rock fissures) and cryptoendoliths (in structural cavities of porous rocks). Endolithic organisms like Cyanobacteria, green algae and photobiont components of lichens penetrate into the rocks through small pores and fissures and widen them gradually by cryogenic disintegration under the impact of freezing-thawing of the water containing biomass causing biochemical weathering (Friedmann, 1982). The light penetrating inside the rock through micro-fissures are the primary light source for these photosynthetic microbes. Some light is also refracted by the translucent grains of quartz and feldspars, which are one of the primary structural ingredients of Antarctic rocks. The source of moisture is the falling snows which accumulate in the small cavities and fissures on rock surface and supply water by melting. Some endolithic communities also have capacity to absorb moisture from the air and to store it inside, which act as an additional source of water supply. The inorganic nutrients required by endolithic microorganisms like Nitrates and Ammonium compounds are generally present in the upper few centimeters of Antarctic rocks (Friedmann & Kibler, 1980). Nitrogenous compounds are abiotically fixed in the upper atmosphere, are conveyed to the rock by snow fallout, which is the probable reason of occurrences of non-heterocystous Cyanobacteria in Antarctic rocks (Friedmann, 1982). This endolithic microbial growth leads to stratification characterized by different coloured bands. This stratification is maintained because of different physiological requirements (exposure to different solar radiation) and abilities (production of antimicrobial substances) of each microbial type (Ocampo-Friedmann & Friedmann, 1993). The cyanobacterial and algal colonization is represented by green coloured band due to the presence of Cyanobacteria like *Chroococcidiopsis*, *Gloeocapsa*, *Plectonema*, *Gloeocapsopsis*, *Synechocystis* and *Cyanothece* along with coccal green algal members like *Trebouxia* and *Hemichloris antarctica*. This indigenous micro-flora within Antarctic rocks was also studied by several researchers time to time (Broady, 1981; Friedmann & al., 1988; Siebert & al., 1996; Banerjee & al., 2000; de la Torre & al., 2003; de los Rios & al., 2004; Wierzchos & al., 2004; Mataloni & Komarek, 2004; Onofri & al., 2007; Büdel & al., 2008; Yung & al., 2014).

MATERIALS AND METHODS

The Larsemann Hills (69°20′–69°30′S and 75°55′–76°30′E) is a 50 km^2 stretch ice-free oasis with two main Peninsulas, Broknes and Stornes. The mean temperature of the warmest month (January) is +0.6 °C and the mean temperature of the coldest month (August) is -15.9 °C. The bedrock in this locality is represented by granitoid formations with granites and granite gneisses consisting of feldspars, quartz, garnet and biotite (Mergelov & al., 2012).

During the XXXV Indian Scientific Expedition to Antarctica in 2015–2016, some rocks with endolithic communities were collected from Broknes peninsula (69°22′48.8′S and 76°17′ 21.4′ E) of Larsemann Hills by one of the authors (DS). The samples were deposited in the algal section of Cryptogamic unit of Central National Herbarium, Howrah (CAL). The Cyanobacteria and algae were scrapped up using forcep and scalpel. Scanning Electron Microscopic study was made using FEI Quanta 200 Scanning Electron Microscope. The identified cyanobacterium has proven refractory to culture and so has been described only by morphological studies made under Scanning Electron Microscope.

RESULTS AND DISCUSSION

The sampled piece of bed rock from Larsemann Hills, East Antarctica (Fig. 1a-b) is a hybrid rock; a mixture of earlier metasediment (the dark grey portions) impregnated by later quartzofeldpathic melt material (pinkish portion). The metasediments must have suffered high pressure-temperature to the tune of 6-7 kilobar and >700 °C and the rocks have also suffered lot of dynamic stress. The rock has a distinct green coloured band of 2.0 – 2.5 millimeter width in the middle of the metasedimentary stratifications. Crusts of the green coloured rock (Fig. 1c) were studied under Scanning Electron Microscope. The surface of the rock was found covered by an organomineral film with closely adhering patches of coccal cyanobacterial community (Fig. 1d), which was identified as a taxon of *Chroococcidiopsis*

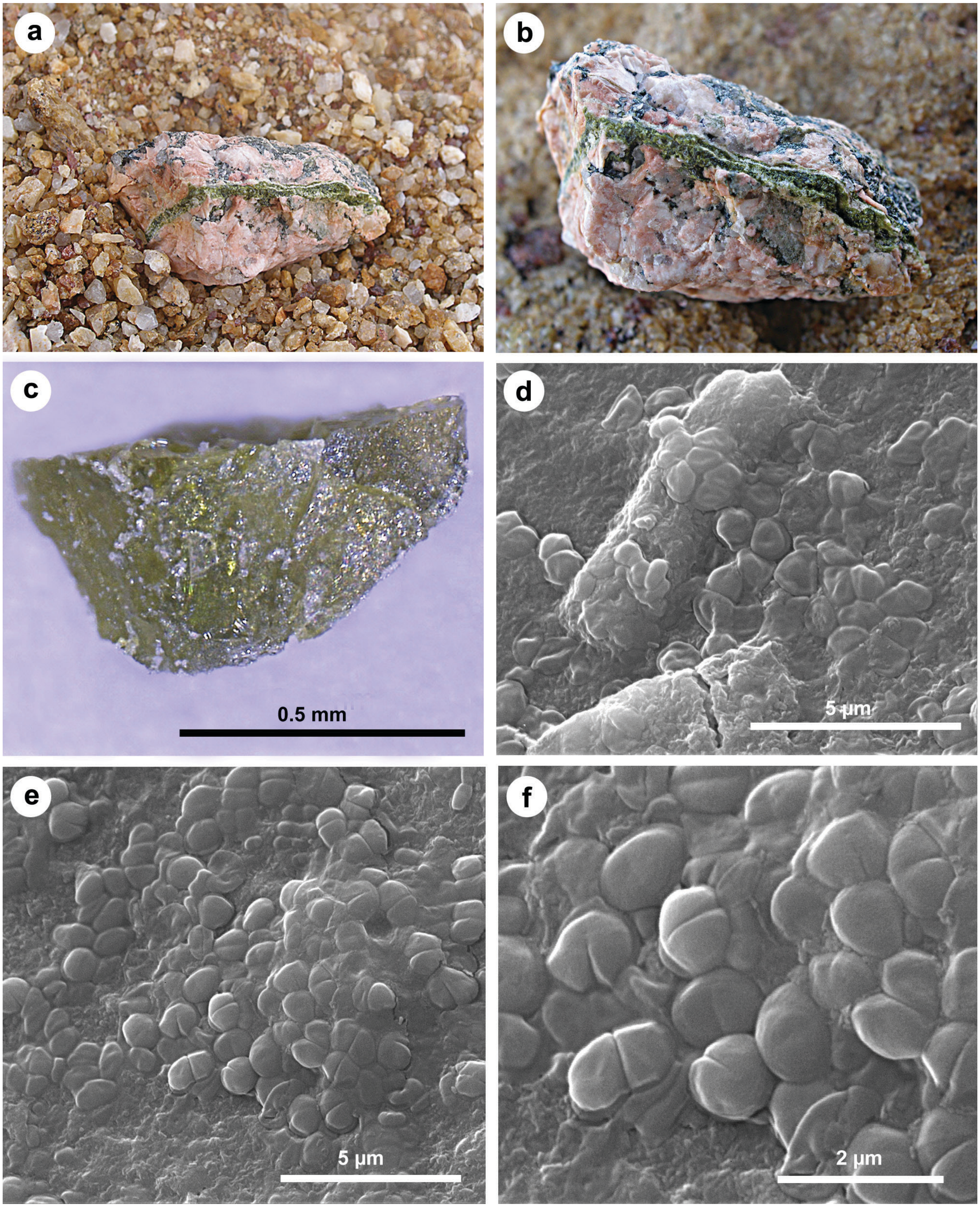

Fig. 1: *Chroococcidiopsis* sp. a–b. Bed rock of Larsemann Hills showing cryptoendolithic microbial growth (in green band); c. Small piece of rock isolated from the green band for microscopic study; d, e. Cells embedded in the organomineral film; f. The same portion enlarged showing binary fission of *Chroococcidiopsis* cells.

Geitler. Cells of *Chroococcidiopsis* are spherical to rounded (Fig. 1e-f), in irregular groups, enveloped by gelatinized sheath. Cells 1.6 – 2.0 µm long, 0.8 – 1.2 µm broad and dividing in various planes by binary fission (Fig. 1f). The species authentication was not possible as there was no satisfactory phenological feature to delimit the taxon at the species level.

The genus *Chroococcidiopsis*, is the most abundant endolithic organism, reported from the Dry Valleys of Antarctica as well as from other desiccated microhabitats around the planet. Due to their high stress tolerant ability, they are treated as potential strains for astrobiological research aimed at establishing the limits of life beyond earth and collection of past life in extra-terrestrial habitats, such as Mars. The study on this aspect was accelerated since 1970, when the Antarctic dry valleys have been considered as the closest terrestrial analog of the Martian environment. To survive in the inhospitable environments of Antarctica, microbes find refuge in the endolithic niche which is a more effective shelter from the outside environment than do soils (Friedmann, 1982). During this harsher period, they evolve by adapting to the environmental conditions, thus sometimes can be considered as examples of primitive life.

ACKNOWLEDGEMENTS

The authors are grateful to the Dr. Paramjit Singh, Director, Botanical Survey of India for facilities and encouragement. Sincere thanks are also to the Director, National Centre for Antarctic and Ocean Research, Goa for providing opportunity for participation of one of us (DS) in XXXV ISEA, indebted to the team leader Dr. Shailendra Saini, Scientist 'D', NCAOR and the team members of the expedition for their untiring help and cooperation, also thankful to Dr. Joy Gopal Ghosh, Director, NCEGR, Geological Survey of India for his valuable remarks on the geological features of the samples.

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