

***Subterraniophyllum thomasii* Elliott, Fossil Calcareous Alga the Evolutionary Link between Geniculate and Nongeniculate Coralline Algae: A Hypothesis**

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Received June 12, 2011; revised July 27, 2011; accepted September 3, 2011

Abstract

The Neogene sediments exposed in the Saurashtra region along the southwest coast India, consists of well preserved diversified coralline algae [1-5]. The *Subterraniophyllum thomasii* Elliott, a fossil Calcareous alga has been reported from the Dwarka Formation (Lower to Middle Miocene) from Porbandar area, Saurashtra, Indian subcontinent. This is the first report of *Subterraniophyllum thomasii* Elliott from Lower-Middle Miocene sediments from the Indian subcontinent; however it has been documented earlier from Late Lutetian sediments of Kachchh Basin, India. There is a controversy regarding the generic placement of the extinct species *Subterraniophyllum thomasii* Elliott as distinct genus of the geniculate coralline algae or not i.e. nongeniculate coralline algae [6,7]. However, the present specimens of *Subterraniophyllum thomasii* Elliott exhibit pinpointing features of both geniculate and nongeniculate coralline algae. Finally on the basis of our observations, we hypothesize that *Subterraniophyllum thomasii* Elliott may be transitional species and evolutionary link between geniculate and nongeniculate coralline algae.

Keywords: *Subterraniophyllum thomasii* Elliott, Evolutionary Link, India

1. Introduction

The Cenozoic sediments of the Porbandar area are classified as Gaj Formation (Lower Miocene), Dwarka Formation (Lower-Middle Miocene), Miliolite Formation (Early Middle-Late Pleistocene) and Chaya Formation (Late Pleistocene-Late Holocene) [8] (**Figure 1**). Coralline algae are the dominant constituents of shallow water sedimentary rocks throughout the Cenozoic Era [9] and they have also a potential as paleo-environmental and paleo-bathymetrical indicators, which are deduced by comparison of fossil algal assemblage with environmental and geographical distribution of modern algal associations [10,11]. The paper incorporates the observations made during the present study; the discussion on the placement of *Subterraniophyllum thomasii* Elliott and proposal of a hypothesis which would throw some light on the anatomy of this species and possibly help to find the placement of this species within Corallinales.

2. Methodology

The thin sections of algae bearing rock sample have been prepared and examined under Lieca-Make Binocular Petrological Microscope. Seventeen sample of *Subterraniophyllum thomasii* Elliott have been observed and analyzed.

3. Classification and Taxonomy

Division: Rhodophyta Wittstein, 1901

Class: Rhodophyceae Rabenhorst, 1863

Order: Corallinales Silva and Johansen, 1986

Family: Corallinaceae Verheij, 1993

Subfamily: Corallinoideae ?

Genus: *Subterraniophyllum* Elliott

Species: *Subterraniophyllum thomasii* Elliott

4. Systematic Description

The segments consist of cylindrical intergenicula with

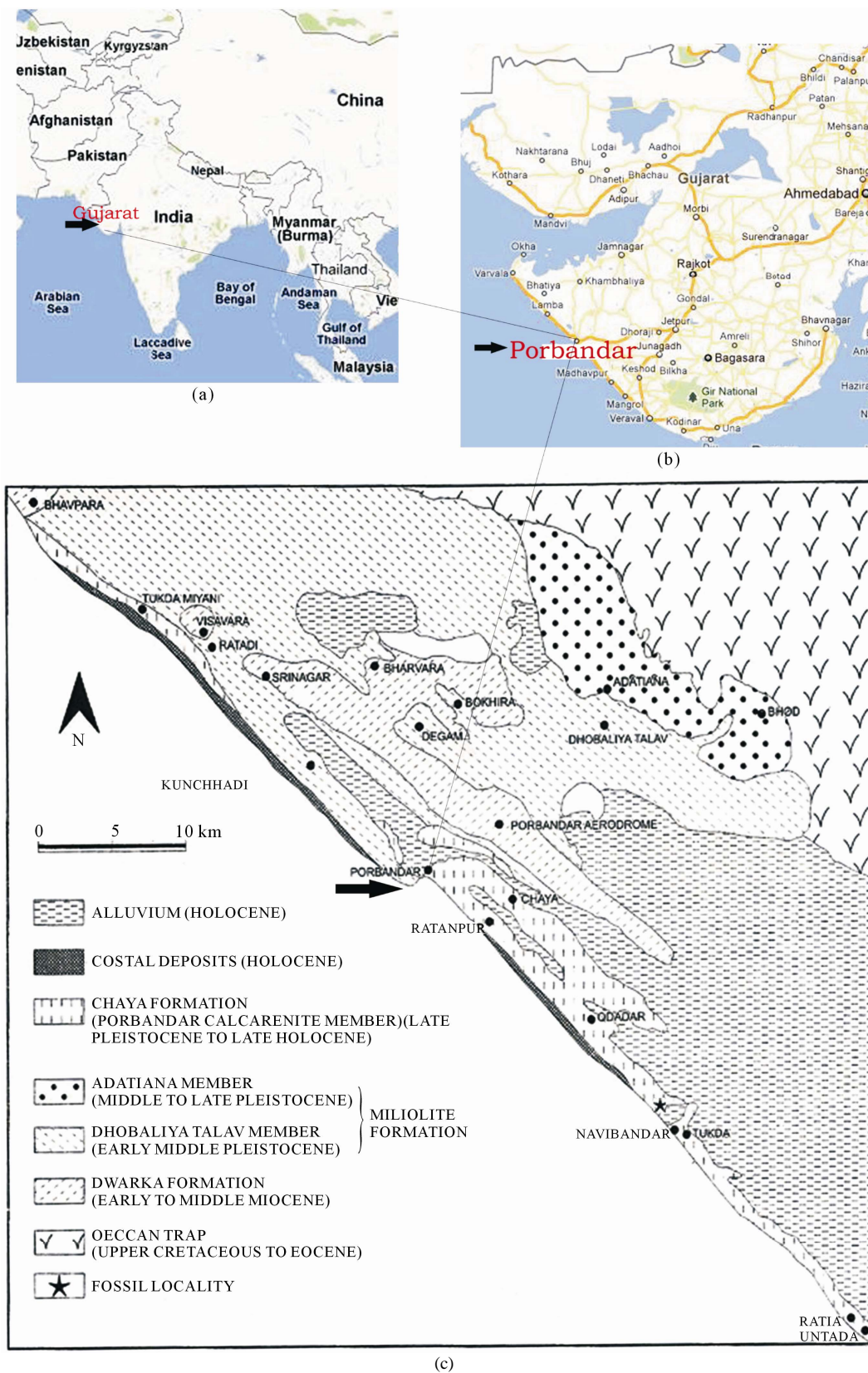


Figure 1. (a) Location Map of India (after Google Map); (b) location Map of India (after Google Map); (c) geological map of the study area (after Mathur *et al.*, 1988).

medullary and cortical region. Medullary cells are trapezoidal in shape. Cell fusion is common in both medullary and cortical cells (**Plate 1, (a) & (b)**). All medullary cells are arranged in irregular tiers. Cortical cells are sub-rectangular to polygonal radiating towards both the margins and smaller in size as compared to medullary cells. Bifurcation is prominent (**Plate 1 (a)** and **(c)**) and dimensions of the various cells are mentioned in **Table 1**.

The length of medullary cells ranges from 32 μm to 50 μm (LMC) except for specimen 509, where 20 μm to 28 μm and width of these cells varies from 16 μm to 24 μm (WMC). The specimen no. 502, 503, 506 and 520, consists of cortical cell, ranging from 10 μm to 20 μm in length (LCC) and 8 μm to 12 μm in width (WCC). The cortical cells are polygonal and the cell wall material is almost black to grey (**Plate 1, (d)** and **(e)**). One row of

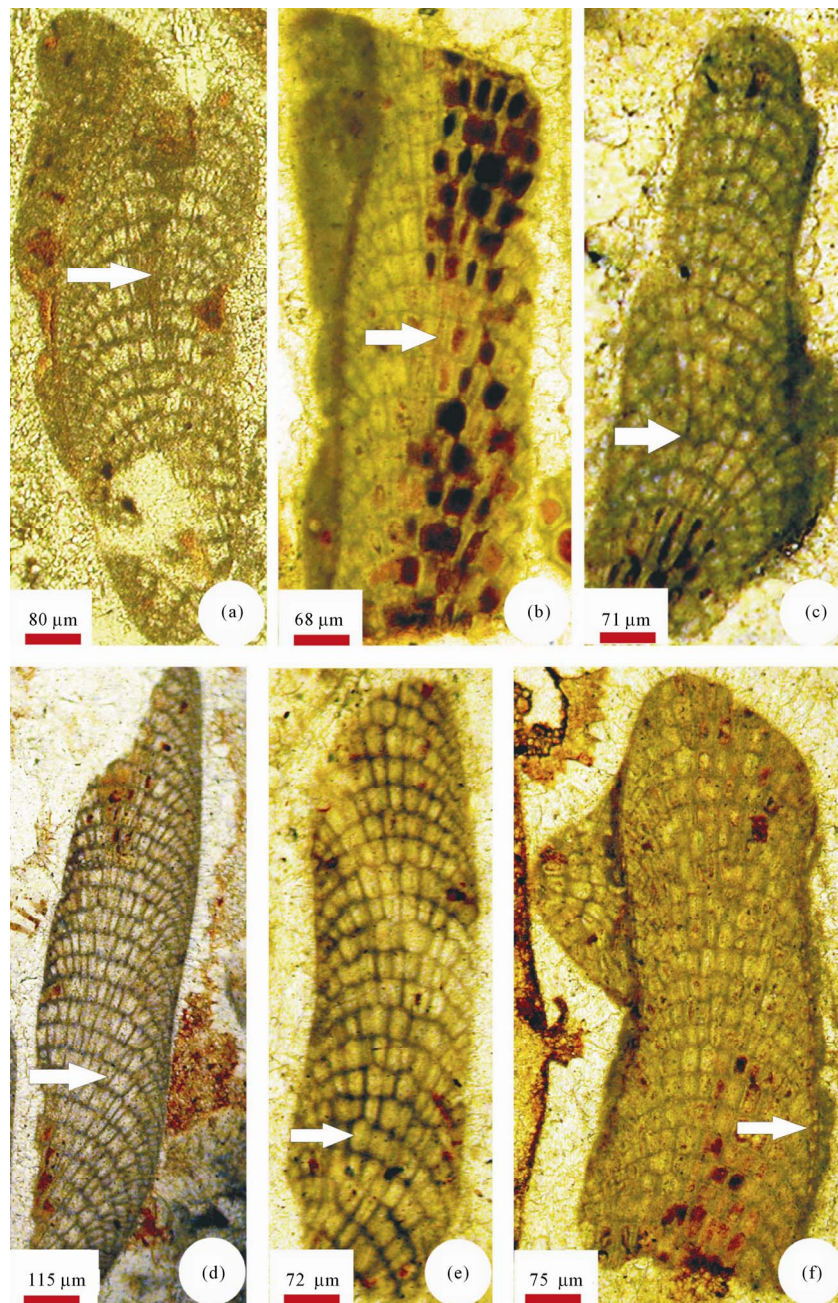


Plate 1. (a) Uniform thickness of the medulla, prominent bifurcation without change in the size/shape of cell at bifurcation/branching; (b) cell fusion in medullary region; (c) prominent bifurcation without change in the size/shape of cell at bifurcation/branching; (d) polygonal cortical cells having black to grey coloured outline; (e) polygonal cortical cells having black to grey coloured outline; (f) one row of rectangular epithelial cells.

Table 1. Dimensions (μm).

SN	LMC	WMC	LCC	WCC
501	40-44	16-20	Nil	Nil
502	32-40	18-22	10-12	8
503	52	16	16	12
504	40	20	Nil	Nil
505	40	24	Nil	Nil
506	50	18	12	8
506A	45	18-16	Nil	Nil
507	45	20	Nil	Nil
508	36-40	16-20	Nil	Nil
509	20-28	16-20	Nil	Nil
510	40-44	16-20	Nil	Nil
511	44	24	Nil	Nil
512	36-40	16-20	20	12
513	40	28	Nil	Nil
514	36-44	20	Nil	Nil
514A	40	18	Nil	Nil
514B	44	20-18	Nil	Nil

rectangular epithallial cell is observed in specimen (f) he conceptacles are not observed in the present specimens; however, it has been recorded from Macedonia [7] and India [12].

5. Discussion

The *Subterraniophyllum* is stratigraphically significant as it is restricted to Eocene (Late Lutetian) to Early Miocene (Aquitian) and more frequently in Early Oligocene. It has been earlier recorded from 15 geographic locations from the world, such as Iran, Iraq, Oman, Atlantic Ocean, Caribbean Ocean, Italy, Slovenia, Macedonia, Crete, Greece, Borneo, Indo-Pacific, Madagascar, Cuba and India [12]. This is the first record of *Subterraniophyllum* from Lower to Middle Miocene sediment of the Porbandar area of Southwest coast of the India; however it has been documented from Late Middle Eocene sediments of the Kachchh basin of the India [12].

The specimens described here are collected from limestones of the Dwarka Formation (Lower to Middle Miocene) of the Porbandar Group at Bhavpara and Srinagar villages. The specimens exhibit most of the morphological features as that of geniculate coralline algae, such as uniform medulla, arrangement of medullary cell in tires,

but lacking genicula and conceptacles. Our observations points out that the *Subterraniophyllum* may be geniculate coralline algae without genicula (as it is not yet reported) but at the branching point there is no significant change in cell anatomy which shows its affinity towards nongeniculate coralline algae. Branching pattern in geniculate and nongeniculate coralline algae, have been well discussed [6]. One school of opinions say that *Subterraniophyllum* is a distinct genus of the geniculate coralline algae, belonging to subfamily Corallinoideae of family Corallinaceae [13-16] while other school of opinion questioned the placement of *Subterraniophyllum* as distinct genus of the geniculate coralline algae based no change in cell pattern or size of cells at bifurcation or branching which is diagnostic feature of nongeniculate coralline algae and considered the genus of uncertain position within the Corallinales [6,7]. There are various researchers who worked on this species [17-24].

6. Conclusions

The present specimens of the *Subterraniophyllum thomasi* Elliott are showing characters of both geniculate and non-geniculate coralline algae. The authors have put forward a hypothesis which will possibly through some light on the *Subterraniophyllum thomasi* Elliott and will help to find out the answers regarding the controversies of this genus and species. The *Subterraniophyllum thomasi* Elliott may be an evolutionary link between nongeniculate and geniculate coralline algae. It may be evolved from *Mesophyllum* like ancestor or other nongeniculate coralline algae. In the initial phase of evolution, branching took place without significant anatomical change at the point of branching, later; genicula was developed in geniculate coralline algae other than *Subterraniophyllum thomasi* Elliott. Most of the geniculate coralline algae are originated and flourished after the Cretaceous Period and surviving in the present day oceans except *Subterraniophyllum* [6]. As the species *Subterraniophyllum thomasi* Elliott, is associated with the transition phase of transformation of nongeniculate to geniculate coralline algae, they were not survived for a longer time and mostly extinct at the end of Miocene Period.

The present specimen of the *Subterraniophyllum* shows anatomical features of geniculate and nongeniculate coralline algae. Over all morphological features says that the *Subterraniophyllum*, is to be kept in the family Corallinaceae of the order Corallinales till further rigid conclusion and there is a need to look at the species *Subterraniophyllum thomasi* Elliott as an evolutionary link or transitional species between geniculate and nongeniculate coralline algae.

7. Acknowledgements

The first author is greatly appreciative to Principal, Fergusson College, Pune, Maharashtra, India, for constant encouragement during the preparation of the manuscript and gratified to the Head, Postgraduate Department of Geology, Nagpur, Maharashtra, India, for providing necessary facilities.

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