*Haematococcus pluvialis*, the richest known natural source for astaxanthin and unique properties of astaxanthin, opens very promising possibilities of neutraceutical and pharmaceutical applications for human health and nutrition[8,9].

In India, where increased population rate and poverty face the malnutrition problem, this astaxanthin-rich indigenous alga appears to be a boon. On one side high rate of industrial growth releases high level of carcinogenic components, heavy metals in the natural environment which is leading to the disappearance of natural, beneficial algal population but on the other side the virgin water bodies of the Himalayan region with beneficial microorganisms are living proof of our rich natural resources which can be exploited wisely without disturbing their natural environment and ecological balance. The growth of this micro-alga from green vegetative stage to red sporulating stage is similar to the growth stages of any fruit especially apple of Himachal Pradesh (Figure 1). Therefore, we can conclude that this apple-rich producing state seems to be a promising state for the production of astaxanthin-rich *Haematococcus pluvialis*.

1. Jeejibai, N. and Kumarvel, S., *Indian Hydrobiol.*, 2003, **6**, 129–137.
2. Naguib, Y. M. A., *J. Agric. Food Chem.*, 2000, **48**, 1150–1154.
3. Torrisson, O. J. and Chritiansen, R., *J. Appl. Ichthyol.*, 1995, **11**, 225–230.
4. Britton, G. S., Liaaen-Jensen and Pfander, H., In *Carotenoids* (eds Britton, G. S., Liaaen-Jensen and Pfander, H.), Birkhauser, Basel, 1995.
5. Miki, W., *Pure Appl. Chem.*, 1991, **63**, 141–146.
6. Jyonouchi, H., Sun, S., Tomita, Y. and Gross, M. D., *J. Nutr.*, 1995, **125**, 2483–2492.
7. Tso, M. O. M. and Lam, T. T., U.S. Patent #5527533, 1996.
8. Lorenz, R. T. and Cysewski, G. R., *Trends Biotechnol.*, 2000, **18**, 160–167.
9. Guerin, M., Huntley, M. E. and Olaizola, *Trends Biotechnol.*, 2003, **21**, 210–216.

ACKNOWLEDGEMENTS. We thank the Director, National Botanical Research Institute, Lucknow for providing all necessary facilities. We also thank Director, Institute of Himalayan Bioresources Technology, Palampur for his kind cooperation and encouragement.

Received 21 November 2005; revised accepted 1 March 2006

M. R. SUSEELA*
KIRAN TOPPO

*National Botanical Research Institute, Lucknow 226 001, India*
**For correspondence.*
*e-mail: mrsuseela@yahoo.co.in*

# Arcellaceans (thecamoebians) from core sediments of Priyadarshini Lake, Schirmacher Oasis, Eastern Antarctica

Arcellaceans (thecamoebians) are predominantly freshwater testaceous protozoans found in different geographical settings, from tropical to arctic latitudes. They are inhabitants of mosses, damp soils, freshwater lake bottoms, floating algal mat, etc. and depend upon other protistans, flagellates, diatoms and fragments of mosses and lichens for food supply[1–3]. Their studies in India have been reviewed recently[4]. Certain morphotypes occurring in glacial and periglacial regimes are useful palaeoclimatic indicators. Reported occurrences of 'thecamoebians' from Antarctic environment are not known. The present study is an attempt at identifying arcellaceans in lacustrine sediment core retrieved by indigenously developed coring device by the Antarctica Division of the Geological Survey of India.

The periglacial milieu of Schirmacher Oasis in Central Dronning Maud Land, East Antarctica is characterized by typically deglaciated landscape interspersed with more than hundred freshwater lakes (Figure 1). These have been systematically classified and numbered as proglacial, landlocked or inland and epiglacial lakes that occur in well-defined lineament and glacial basins formed during the late Pleistocene–Holocene period[5]. Priyadarshini Lake (L-49) is one of the largest landlocked lakes having about 0.75 $km^2$ water spread area, which has been studied with respect to biological, sedimentological, hydrogeochemical and limnological aspects in recent years[6–13].

During the austral summer of 2002–03, a shallow sediment core of about 50 cm length was recovered from Priyadarshini Lake (Figure 2) using an indigenously designed and fabricated system. After natural desiccation over a period of six months, the core length was reduced to 32 cm. In all, five samples (Figure 3) were macerated using standard procedures and dried at low temperature (60 to 80°C). The dried material was examined under Leica MZ 12 Stereozoom Microscope (by A. K. M.). Samples L 49/2 (from 20 to 26 cm) and L 4/3 (from 14 to 20 cm) contain 'thecamoebians' (Figure 4), which were subsequently studied under Leo 440 Scanning Electron Microscope and are described below.

Subphyllum: Sarcodina Schmarda 1871.
Class: Rhizopoda von Sieboid 1845.
Subclass: Lobosa Carpenter 1861.
Order: Arcellinda Kent 1880.
Superfamily: Arcellacea Ehrenberg 1830.
Family: Arcellidae Ehrenberg 1830.
Genus: Arcella Ehrenberg 1830.

*Arcella patens Antarctica* n. subsp. (Figure 4 *a*, *b*).

Material: One test from sample L 49/2, Priyadarshini Lake, E. Antarctica.

Diagnosis: Test very small, ovoid cylindrical, slightly compressed, membranous, hyaline, translucent, aperture large elliptical invaginate, aperture rim narrow, texture minutely cancellate in light microscope, thecal plates irregularly shaped, height two-thirds of width.

Diameter: 75 µm; height: 50 µm (Figure 3 *a*, *b* – Holotype).

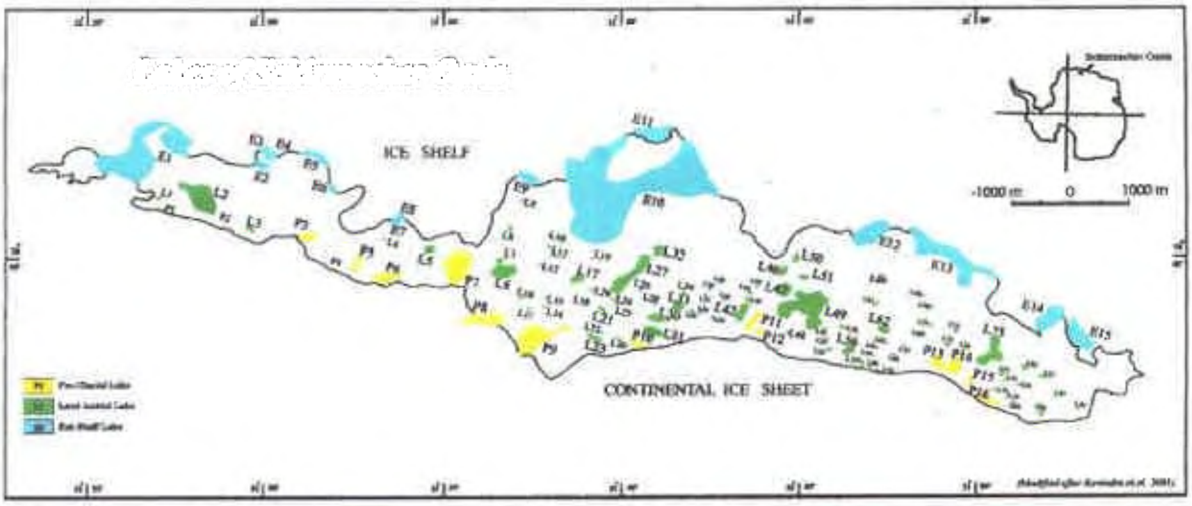


**Figure 1.** Lakes of Schirmacher Oasis.

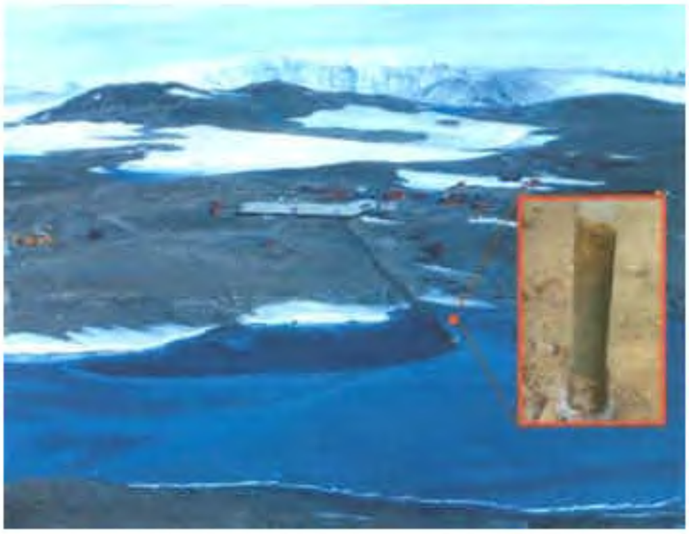

**Figure 2.** Sediment core from Priyadarshini Lake.

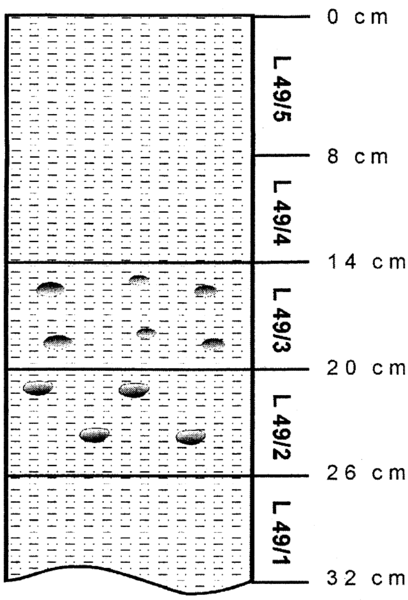


**Figure 3.** Samples examined.

Remarks: The present specimen resembles *Arcela patens* Claparede and Lachmann in large invaginate aperture, but differs from it in having elliptical rather than circular aperture and is very small in size, 75 μm, compared to 220 μm for *A. patens*. It is therefore necessary to place the new form as a subspecies/strain of *A. patensn* known from bogs of Berlin, Germany[14].

Name: The subspecies/strain has been named after the continent Antarctica from where it has been recovered for the first time.

Age: Late Pleistocene–Holocene.
Family: Difflugiidae Wallich 1864.

Genus: *Difflugia* Lecerc in Lamarck 1816.
*Difflugia* sp. (Figure 4 *c*).

Material: One test from sample L 49/3, Priyardarshini Lake, E. Antarctica.

Diameter: 100 μm; height 75 μm (Figure 2 *c* – Hypotype).

Diagnosis: Test semi-globose, truncated anteriorly, aperture medium, shallow, neck obsolete, surface covered with irregular grains of quartz.

Remarks: The present specimen resembles, to some extent, *Difflugia corona* Wallich in overall shape, but differs from it in being small in size (100 μm), having semi-globose test truncated anteriorly, instead of ovo-globose, large (> 220 μm) test, neck-like protrusion anteriorly and posterior spines.

The thecamoebians are important ecological indicators around the world, especially in freshwater lakes of colder regions with varying pH and dissolved solids. This record in Antarctica is of significance in building limnological history of the continent, which is still poorly understood. *A. patens*, of which *Arcella patens*

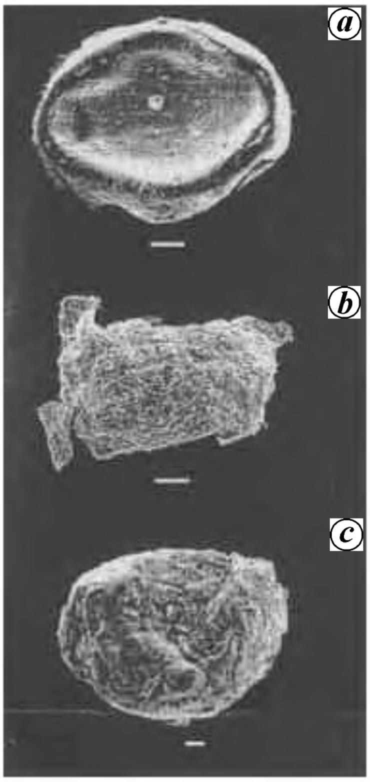


**Figure 4.** Samples containing thecamoebians.

*Antarctica* is described here as a subspecies, is known from bogs in Germany[14]. *Arcella vulgaris*, which is an important arcellacean, is known from the bogs in Arctic and further south in the Canadian region with pH[15] varying from 2.1 to 5.7. The *Difflugia* group apparently dominates in the water with higher pH of 6.7 or more[15]. Though the present assemblage is poor in content, the reflection of change in water pH is discernible from L-49/2 (with low pH and low dissolved solids, inhabited by *A. antarctica*) to L-49/3 (with higher pH inhabited by *Difflugia* sp.) in the Late Pleistocene–Holocene lake sediments.

1. Loeblich, A. R. and Tappan, H., *Treatise on Invertebrate Palaeontology, Part C (Protista)* (ed. Moore, R. C.), Geological Society of America and University of Kansas, 1964, pp. C16–C54.
2. McCarthy, F. M. G., Collins, E. S., McAndrew, J. H., Kerr, H. A., Scott, D. B. and Medioli, F. S., *J. Palaeontol.*, 1995, **69**, 980–993.
3. Medioli, F. S. and Scott, D. B., *Palaeogeogr. Palaeoclimatol. Palaeoecol.*, 1988, **62**, 361–386.
4. Mehra, S., Mathur, A. K. and Mehrotra, S. C., Proc. South Asia Geological Congress (GEOSAS-IV), New Delhi, Geological Survey of India, 2003, pp. 328–335.
5. Ravindra, R., Chaturvedi, A. and Beg, M. J., In *Advances in Marine and Antarctic Science* (eds Schoo, D. B. and Pandey, P. C.), New Delhi, 2002, pp. 301–313.
6. Ingole, B. and Dhargalkar, V., *Curr. Sci.*, 1998, **74**, 529–534.
7. Sinha, R., Chatterjee, A., Panda, A. K. and Mitra, A., *Curr. Sci.*, 1999, **76**, 680–683.
8. Sinha, R., Navada, S. V., Chatterjee, A., Sarvan Kumar, Mitra, A. and Nair, A. R., *Curr. Sci.*, 2000, **78**, 992–995.
9. Sinha, R. and Chatterjee, A., *J. Geol. Soc. India*, 2000, **56**, 39–45.
10. Sinha, R., Sharma, C. and Chauhan, M. S., *Palaeobotanist*, 2000, **49**, 1–8.
11. Sinha, R., Sastry, V. N. and Rajagopalan, G., *J. Geol. Soc. India*, 2003, **61**, 717–723.
12. Kumar, P., Mohammed, R. S. and Mehrotra, Scientific Report. Dept of Ocean Dev., Tech. Publ., 2002, vol. 16, pp. 273–292.
13. Bera, S. K., *Curr. Sci.*, 2004, **86**, 1485–1488.
14. Claparede and Lachmmann in Carter, H. J., *Ann. Mag. Nat. Hist. Ser. 3*, 1864, **xiii**, 18–39.
15. Patterson, R. T. and Arun Kumar, *J. Foram. Res.*, 2000, **30**, 310–320.

ACKNOWLEDGEMENTS. Sediment core was collected during the 22nd Indian Antarctic Expedition. The Director, National Centre for Antarctic and Ocean Research (Department of Ocean Development) and Director General, Geological Survey of India are acknowledged for providing logistics and permission to publish this paper. R.A. thanks fellow expedition members for assistance in core extraction.

Received 18 January 2006; accepted 28 March 2006

ANIL K. MATHUR[1]
R. ASTHANA[2]
RASIK RAVINDRA[2,*]

[1]*Geological Survey of India, Sector E, Aliganj, Lucknow 226 024, India*
[2]*Antarctica Division, Geological Survey of India, NH-5P, NIT, Faridabad 121 001, India*
**For correspondence.*
*e-mail: antgsi@vsnl.net*

# Energy for geodynamics: Mantle decompression thermal-tsunami

It is known through experience in deep mines and with bore-holes that temperature increases with depth in the crust. For more than half a century geophysicists have made measurements of near-surface continental and oceanic heat flow with the aim of determining the Earth's heat loss. Pollack *et al.*[1] estimate a global heat loss of 44.2 TW (1 TW = $10^{12}$ W) based upon 24,774 observations at 20,201 sites.

Numerous attempts have been made to reconcile measured global heat loss with radionuclide heat production from various geophysical models closely involved with plate tectonics. Usually, models are contrived to yield the very result they model, but in this case there is a problem. Currently popular models rely upon radiogenic heat for geodynamic processes, geomagnetic field generation, and for the Earth's heat loss. The problem is that radionuclides cannot even satisfy just the global heat loss requirements.

Previous estimates of global heat production invariably come from the more-or-less general assumption that the Earth's current heat loss consists of the steady-state heat production from long-lived radionuclides ($^{235}$U, $^{238}$U, $^{232}$Th, and $^{40}$K). Estimates of present-day global radiogenic heat production, based upon chondritic abundances, typically range from 19 TW to 31 TW. These represent an upper limit through the tacit assumption of rapid heat transport irrespective of assumed radionuclide locations. The short-fall in heat production, relative to Earth's measured heat loss[1], has led to speculation that the difference might be accounted for by residual heat from Earth's formation $4.5 \times 10^9$ years ago, ancient radiogenic heat from a time of greater heat production, or, perhaps, from a yet unidentified heat source[2].

The purpose of this brief communication is to disclose a heretofore unanticipated heat transport mechanism and heat source capable of emplacing heat at the mantle–crust-interface at the base of the crust.

Since the first hypothesis about the origin of the sun and the planets was advanced in the latter half of the 18th century by Immanuel Kant and modified