Chitinozoa and melanosclerite from the Lower Paleozoic sequence of the Tethyan Garhwal Himalaya – A note on their identification and distinction

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Sediments of the Shiala and Yong Limestone formations belonging to the marine Lower Paleozoic sequence in the Tethyan Garhwal Himalaya have yielded a rich assemblage of acritarchs. In addition to prolific occurrence of acritarchs, these sediments have also yielded rare to infrequent chitinozoa and melanosclerite. It is pointed out that the distinction between these two distinct palynological entities is rather difficult through the conventional microscopic examination. The present paper highlights the subtle and minor differences in the morphologies of the two which could be seen only through SEM. Thus, a thorough rechecking and revision of earlier records is necessary for correct identification.

THE present study reveals the occurrence of rare presence of chitinozoa and melanosclerite along with prolific acritarchs[1] from the Shiala and Yong Limestone formations. These formations of the Tethyan Garhwal Himalaya are well exposed in and around the village Sumna (30°40′N, 80°50′E) of the Chamoli district of the Garhwal Division, Uttar Pradesh. The lithostratigraphic framework at Sumna has already been described[2,3] (Table 1).

The Garbyang Formation grades into the Shiala Formation without any lithological change[2]. Four biostratigraphic zones have been established based on macrofauna and Middle to Upper Ordovician age has been assigned to the Shiala Formation[2,3]. However, Middle Ordovician age is assigned to the Shiala Formation based on conodont species[4]. But, Caradocian to Wenlockian age is assigned to the Shiala Formation based on the acritarch assemblages recorded[1]. The Yong Limestone is biohermal in nature and is recognized as a separate lithostratigraphic unit, named as the Yong Limestone Formation which conformably overlies the Shiala Formation. An Upper Ordovician to Lower Silurian age has been assigned to the Yong Limestone[2,3,5]. However, Sinha *et al.*[1] have dated the Yong Limestone Formation to be of Late Silurian age (Ludlovian) based on acritarch assemblage.

The method of preparation of strato–litho–petrographic column and the traverse direction for sample collection along the Sumna–Rimkhim section has been described elsewhere[1].

The samples collected from the Shiala and the Yong Limestone formations are clastics and non-clastics which include mainly fine-grained calcareous quartz arenite, siltyshale and wackstone (bioclast).

From each sample, 50 g of pea-sized rock material was dissolved first in hydrochloric acid and then in hydrofluoric acid and finally in nitric acid. The macerated and decomposed material was washed four times with distilled water by centrifuging. Material thus obtained was treated with heavy liquid using KI, CdI_2 and ZnI. The permanent slide was prepared by adding 2 drops of polyvinyl alcohol into the residue. All the slides and samples are deposited at the Department of Earth Sciences, University of Roorkee for future reference.

Chitinozoans are a group of acid-resistant microfossils whose biological affinities are yet to be ascertained[6–8]. It is believed that they represent the eggs or egg capsules of a soft-bodied metazoan[9,10]. They occur singly or in colonies[7], containing twelve or more individual vesicles[6]. Few chitinozoans show polymorphism phenomenon[7]. Eisenack[11] first recorded chitinozoans in Germany in 1931. Chitinozoans have been described from almost all the continents, with the single exception of Antarctica[12]. They are exclusively marine planktic microfossils found in sedimentary rocks ranging in age from Ordovician to Devonian[8]. They have been reported from Mississippian rocks also[13]. They occur in Paleozoic shale and limestones; and are found to be rare in coarse grained limestone and sandstone due to the winnowing action of prevailing current[14]. They are generally flask-shaped[14] and range in size from 60 to 2,000 microns[15] but the majority of species have a size range between 100 and 300 microns[6]. Due to their rapid evolution, wide distribution and short ranging species of chitinozoa permit a detailed biozonation of Palaeozoic strata[8,15]. It has been shown that the detailed chitinozoan biozonation is possible in sediments that have undergone greenschist facies metamorphism[16]. The first global chitinozoa biozonation for the Silurian has been proposed based on short ranging, well-defined and easily identifiable index

Table 1. Lithostratigraphic framework of the Tethyan Garhwal Himalaya (Sinha, 1989)

Time unit	Lithounit	Generalized lithology
Silurian	Yong Limestone Formation	Green nodular limestone
Ordovician	Shiala Formation	Sandstone, quartzite, limestone, alternate bands of sandstone and shale, alternate bands of greenish shale and limestone
	Garbyang Formation	Green needle shale with occasional bands of limestone, sandstone and shale

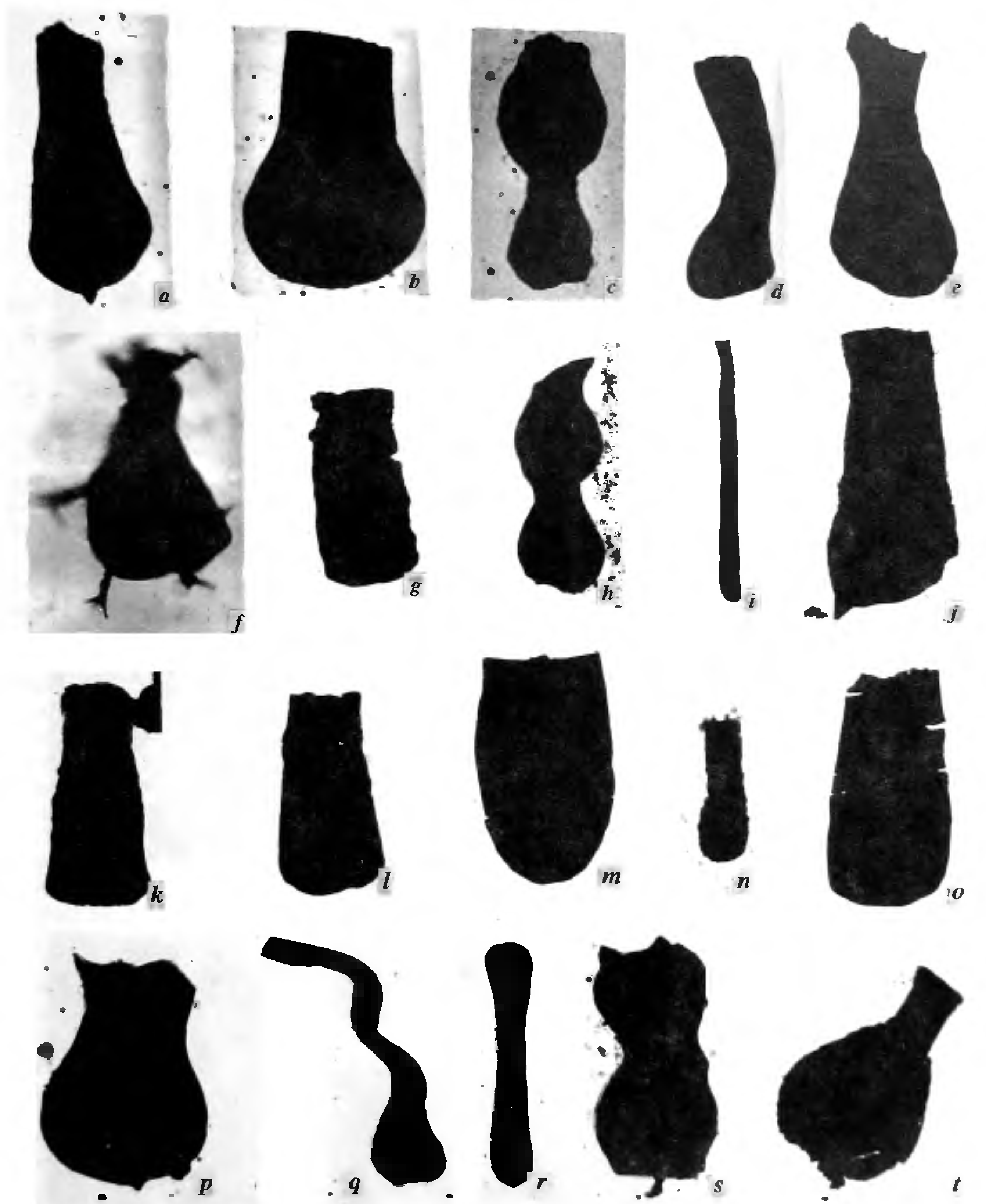

Figure 1 *a*–*t*. Palynological slide photographs. Figures ***a***, ***b***, ***d***, ***e***, ***g***, ***i***–***t*** are either chitinozoans or melanosclerites. ***a***, sample no. R-44(3), coordinate 110 × 56.6, L = 60 μm. ***b***, sample no. R-43(1), coordinate 101.5 × 43.6, L = 75 μm. ***d***, sample no. R-38(3), coordinate 105.7 × 55.3, L = 54 μm. ***e***, sample no. R-39(1), coordinate 110 × 50, L = 70 μm. ***g***, sample no. R-37(1), coordinate 108.5 × 27.3, L = 105 μm. ***i***, sample no. R-50(2), coordinate 112.2 × 49.3, L = 240 μm. ***j***, sample no. R-35(2), coordinate 99.6 × 49, L = 60 μm. ***k***, sample no. R-37(1), coordinate 101.1 × 38.9, L = 120 μm. ***l***, sample no. R-37(1), coordinate 98.9 × 40.6, L = 120 μm. ***m***, sample no. R-37(1), coordinate 97.5 × 44.5, L = 110 μm. ***n***, sample no. R-41, coordinate 99.5 × 17, L = 50 μm (thin section). ***o***, sample no. R-37(2), coordinate 97.6 × 50.7, L = 62 μm. ***p***, sample no. R-43(2), coordinate 105 × 45.4, L = 54 μm. ***q***, sample no. R-40(1), coordinate 105.9 × 46, L = 82 μm. ***r***, sample no. R- 43(2), coordinate 97 × 43.5, L = 112 μm. ***s***, sample no. R-44(2), coordinate 104.1 × 39.6, L = 50 μm. ***t***, sample no. R-40(1), coordinate 107.6 × 59.5, L = 54 μm. Chitinozoans: ***c***, *Desmochitina* sp., sample no. R- 40(1), coordinate 95.1 × 35.8, L = 44 μm. ***f***, *Ancyrochitina* sp., sample no. R-20(1), coordinate 93.9 × 51, L = 48 μm. ***h***, *Desmochitina* sp., sample no. R- 40(1), coordinate 91.5 × 61.5, L = 66 μm.

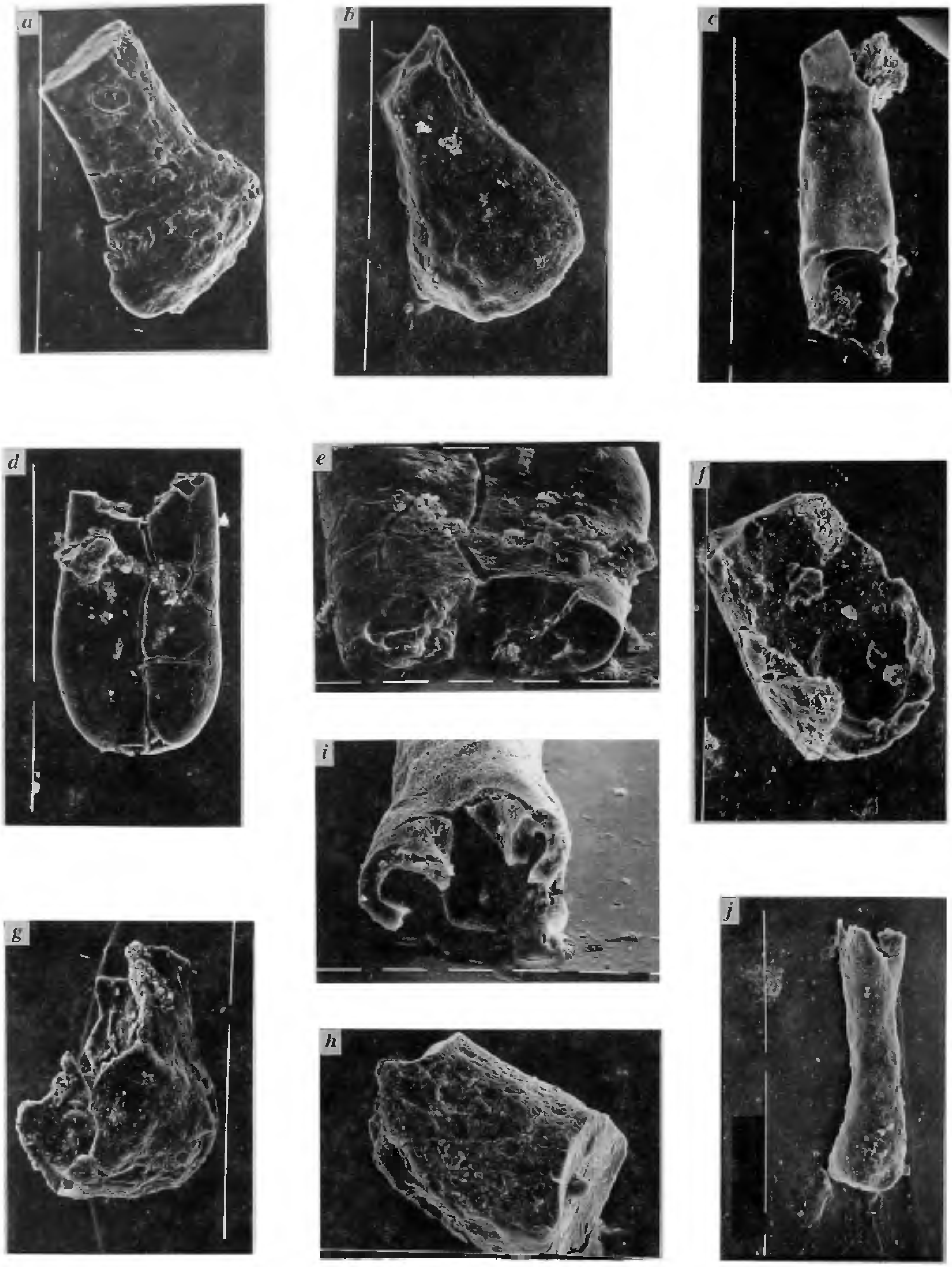

Figure 2 *a–j*. SEM photographs. ***a***, ***b***, Melanosclerites: ***a***, sample no. R-43 (×750), ***b***, sample no. R-41 (×750) (not hollow); ***c***, aff. ***Conochitina*** sp. (broken), sample no. R-43 (×500); ***d***, ***e***: melanosclerite, ***d***, sample no. R-43 (×750); ***e***, showing thickness of the wall of figure ***d*** (×1500); ***f***, ***g***: looks like a *Bursachitina* sp. but is likely a melanosclerite, ***f***, sample no. R- 41 (×750), ***g***, tilted view (×750); ***h***, fragment of melanosclerite, sample no. R-42 (×750); ***i***, ***j***: melanosclerite, ***i***, thick wall (×1500), ***j***, sample no. R- 41 (×500).

Table 2.

Features	Chitinozoans	Figure no.	Melanosclerites	Figure no.
Thickness of wall	Thin walled*	2 *c*	Thick walled*	2 *d, e, i, j*
Nature of vesicles	Hollow vesicles	2 *c, f, g*	Generally not hollow	2 *a* and *b*
Nature of central canal	–	–	Very small central canal	2 *h*

Light microscopic studies shown in Figure 1 *a, b, d, e, g, i–t* (Palynological slide) could either be chitinozoans or melanosclerites.
*Thickness of wall of melanosclerites is relatively more than the thickness of wall of chitinozoans in general.

species[8]. The chitinozoans are found to be most diverse and abundant in the subtidal deposits[17].

The palaeogeographical studies of chitinozoan distribution are scanty[18]. However, the chitinozoan provincialism is less pronounced in Silurian than in the Ordovician on generic level[18,19].

The chitinozoa described from the Shiala and the Yong Limestone formations are black and very glossy under normal light (Figure 1). The black colour of fossils may be due to progressive increase of the carbon ratio, i.e. overmaturity[20] caused by eometamorphism[21]. Cramer *et al.*[21] suggested that the black colour of chitinozoa is possibly due to the temperature exposure of about 200°C.

The term 'Melanosclerite' was first used by Eisenack[22] to identify the problematic microfossils ranging in age from Ordovician to Middle Devonian (Eifelian age)[22]. Melanosclerites are exclusively marine rod-shaped microfossils with pseudochitinous wall composition[23], i.e. not very close to true chitin but similar to the composition of the shells of the Recent Thecamoeba *Gromia oviformis*[24]. They have not been widely studied and are considered to have some affinity with hydrozoans[23]. An algal origin for melanosclerites is also suggested[25]. They are strongly facies controlled and restricted in sediments formed under open ocean conditions[26]. However, Cashman[23] found a similarity in ecology and latitudinal occurrence between the modern cubomedusa, *Carybdea alata* and melanosclerite *Melanostylus coronifer*. This could be helpful in palaeoenvironmental and palaeogeographical reconstructions. More study on this problematic microfossil is required for better understanding on the phylogenetic history and their distribution through Phanerozoic. This would help in biostratigraphy and palaeoenvironmental interpretation[23].

The melanosclerites and chitinozoans recovered from the Shiala and the Yong Limestone formations of the Tethyan Garhwal Himalaya are poorly preserved. The chitinozoans recovered by the earlier workers are from the Vindhyan Supergroup (Sone Valley)[27]; Pin dolomite, Spiti[28]; Yong Limestone, Garhwal[5], Spiti[29] and Satpuli, Garhwal[30]. However, the published literature has no record of chitinozoans from the Shiala Formation. In the present study, the generic identification of some of the recovered chitinozoans from Shiala and Yong Limestone formations has been done, which are long ranging in age. They are *Ancyrochitina* sp., *Desmochitina* sp., *Conochitina* sp. (Figures 1 and 2). The generic and specific identification of melanosclerites was not attempted during the present study.

Owing to a very close similarity in size and nature of silhouette of chitinozoans and melanosclerites, there exists every possibility of erroneous identification. It was found that many previously described and illustrated chitinozoan taxa proved to be unworkable when light microscope studies were replaced by routine SEM investigation[12]. Thus, a form identified through a microscope as a chitinozoan may in fact be a melanosclerite. Hence, it may be pointed out that the earlier reports, records and illustrations published particularly from Indian subcontinent may require reexamination, checking, correction and revision through SEM.

In view of this information, the present material was carefully handled and examined before sending for publication.

The principal distinguishing features (which can be seen only under SEM) between the two distinct palynological entities are tabulated in Table 2.

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Gas-charged sediments in shallow waters off Redi along the central west coast of India

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This study reports the occurrence of gas-charged sediments in the nearshore areas of the west coast of India. High resolution shallow seismic reflection profiles on the nearshore area along central west coast of India, at water depths of 11–18 m are characterized by anomalous seismic subbottom signatures in the form of acoustic turbidity which extends from the underlying reflector and reach within 4–5 m of the seafloor. Fine grained sediments apparently contain appreciable quantities of interstitial gas bubbles which are responsible for the anomalous seismic signatures. This could be due to shallow hydrocarbon gases, mostly methane, which might have been derived due to the biogenic degradation of organic matter accumulated under palaeo-estuarine conditions. These gas-charged sediments pose a potential hazard for the offshore engineering constructions. Hence, the detection of these sediments forms an essential part of any offshore site investigation programmes.

THE western continental shelf is widest off Cambay (345 km) and it narrows down (60 km) off Quilon. It is characterized by gently dipping seafloor, with an average gradient of 1 : 400–1 : 3000, and the shelf break occurs at 80 to 140 m water depths. The inner shelf up to 50–60 m water depths is marked by even topography and is carpeted by silts and clays while middle and the outer shelf show uneven to rough topography with a thin layer of calcareous sands.

Recent developments in marine geophysical techniques have made it easier to identify gases in shallow marine sediments. Based on shallow seismic, side scan sonar and echogram results, gas-charged sediments have been reported from most of the world's continental shelves[1–5]. The addition of gaseous phase compounds to the otherwise fluid saturated seafloor sediments significantly alters the acoustic properties of the seafloor[6,7]. These effects produce readily identifiable anomalies in high resolution subbottom reflection profiles of the shallow seafloor[8–10]. Though the occurrence of shallow gas-charged sediments is documented on the western continental margin of India using seismic signatures[11–14], little or no similar information is available so far regarding these in nearshore areas. Here we report the occurrence of gas-charged sediments in the nearshore areas of the west coast of India.

The study area lies in the shallow waters off Redi,

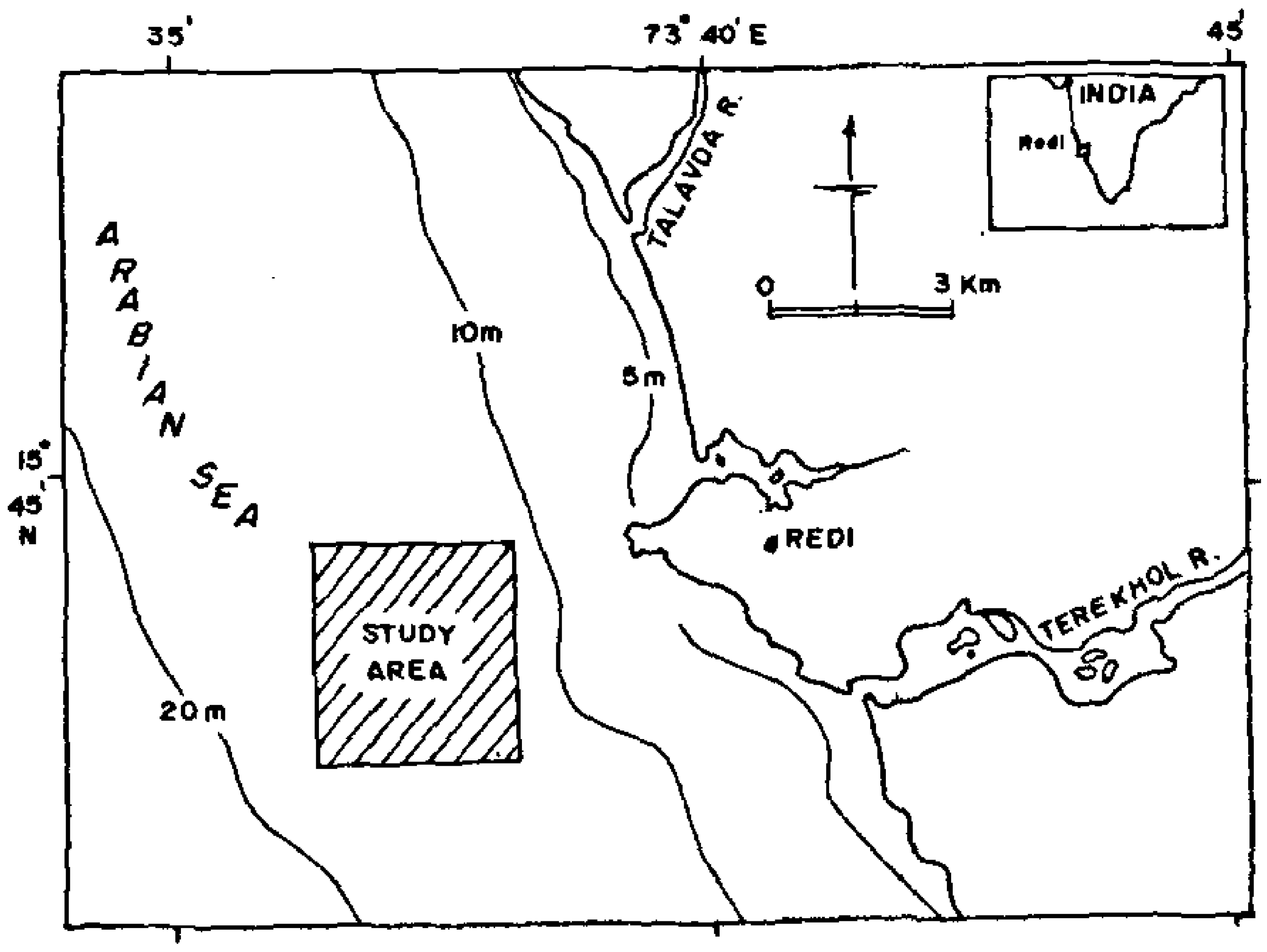

Figure 1. Map showing the survey area off Redi. Inset shows the location of Redi along the west coast of India.