

Soft-shelled benthic foraminifera from a hadal site (7800 m water depth) in the Atacama Trench (SE Pacific): preliminary observations

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ABSTRACT – Soft-shelled foraminifera (organic-walled allogromiids and agglutinated saccamminids) are an important component of the deep-sea meiofauna. Although these largely monothalamous taxa are common at bathyal and abyssal sites in almost all oceans, there are only two records from hadal depths. Here we report the occurrence of numerous allogromiids and saccamminids in a sample collected at 7800 m water depth in the Atacama Trench. The >20 µm fraction of the core sample (0–6 cm layer) yielded a total of 546 soft-walled specimens, the vast majority of them Rose Bengal stained, belonging to 20 morphospecies. Most specimens were allogromiids (82.0%), followed by saccamminids (11.0%) and psammosphaerids (6.0%). Allogromiids, particularly *Nodellum*- and *Resigella*-like forms, were responsible for a distinct peak around 120–160 µm in the size distribution, while the spherical Allogromiid sp. 1 dominated the larger-size classes. This sample provides further evidence for the widespread occurrence of soft-walled monothalamous foraminifera in marine habitats. A form resembling *Resigella* is common in the Atacama Trench sample but has not been observed at abyssal sites in the Pacific Ocean or Atlantic Ocean. *J. Micropalaeontol.* 21(2): 131–135, December 2002.

INTRODUCTION

Soft-shelled foraminifera (organic-walled allogromiids and agglutinated saccamminids) are an important component of the deep-sea meiofauna. These taxa, many of which are monothalamous, are widely reported from bathyal and abyssal sites in the North Atlantic, Indian and Pacific oceans (Gooday, 1996; Gooday *et al.*, 2000, 2001). There are very few records, however, from deep-sea trenches (water depths >6000 m). The purpose of this short paper is to report the occurrence of abundant soft-shelled foraminifera in a sample from hadal depths in the Atacama Trench. A previous study (Danovaro *et al.*, 2002) established the presence of metazoan meiofaunal taxa at this site.

THE STUDY SITE

The Peru–Chile trench is the world's largest trench, extending for about 5900 km with a mean width of 100 km. The section between latitude 20° and 30° S is known as the Atacama Trench and is one of the deepest sectors, reaching >8000 m water depth (23–24° S) at a distance of *c.* 60 km from land. It is located in an area characterized by strong upwelling leading to very high phytoplankton production. There are no rivers in this region, but winds play an important role in transferring material from the adjacent continental desert (Angel, 1982).

CTD profiles indicate that temperatures decreased from about 17°C at the sea surface to *c.* 2°C below 1500 m water depth (Sievers *et al.*, 1999). From 2000 to 5000 m, the temperature slowly decreased down to 1.75°C. Vertical profiles of salinity exhibited a surface layer of highly saline waters (34.90‰), followed by an intermediate layer with a relatively low salinity (34.45‰) and a bottom layer with a constant salinity of 34.64‰ (Sievers *et al.*, 1999). Concentrations of dissolved oxygen followed the salinity profile. For other chemical, physical and biochemical data, see Della Croce *et al.* (1998).

MATERIAL AND METHODS

The sample examined for this study was collected at 23° 15.0' S, 71° 21.0' W (*c.* 7800 m water depth) (Fig. 1) during the Atacama Trench International Expedition (ATIE) (September 1997; *R/V Vidal Gormaz*) using a new experimental single-barrelled corer (Della Croce *et al.*, 1998) and preserved in buffered 10% formalin. The sample had a volume of 20 ml corresponding to 6 cm sediment depth (0–6 cm layer). For a separate study of the metazoan meiofauna (Danovaro *et al.*, 2002), the sample was passed through 1000 µm and 20 µm sieves and the fraction retained in the smaller sieve resuspended, centrifuged three times with Ludox HS40 (density 1.24 g cm⁻³) (Pfannkuche & Thiel, 1988) and stained with Rose Bengal (0.5 g l⁻¹). All soft-walled foraminifera were sorted by hand, under a binocular microscope, from the floated residue. Most individuals were placed in glycerol on a cavity slide; those that undergo substantial shrinkage in glycerol were preserved in 10% formalin in glass vials. Specimens were photographed in glycerol using an Olympus PM-10AD photomicroscope.

RESULTS

A total of 546 soft-walled specimens, almost all of them 'live' (i.e. stained with Rose Bengal), were removed from the residue. Most (82%) were allogromiids with an entirely organic test wall. Saccamminids and psammosphaerids, in which the delicate test wall is predominantly agglutinated, were less common, accounting for 11% and 6% of the assemblage respectively. Two specimens belonged to the delicate astrophorid genus *Vanhoeffenella* in which the upper and lower sides of the flattened test are composed of an organic membrane (Table 1).

Twenty soft-walled foraminiferal morphospecies were recognized, based on test morphology and the presence or absence of accumulations of stercomata within the test. All are undescribed. The two most common species were both organic-walled allogromiids, one a spherical form (Pl. 1, fig. 1),

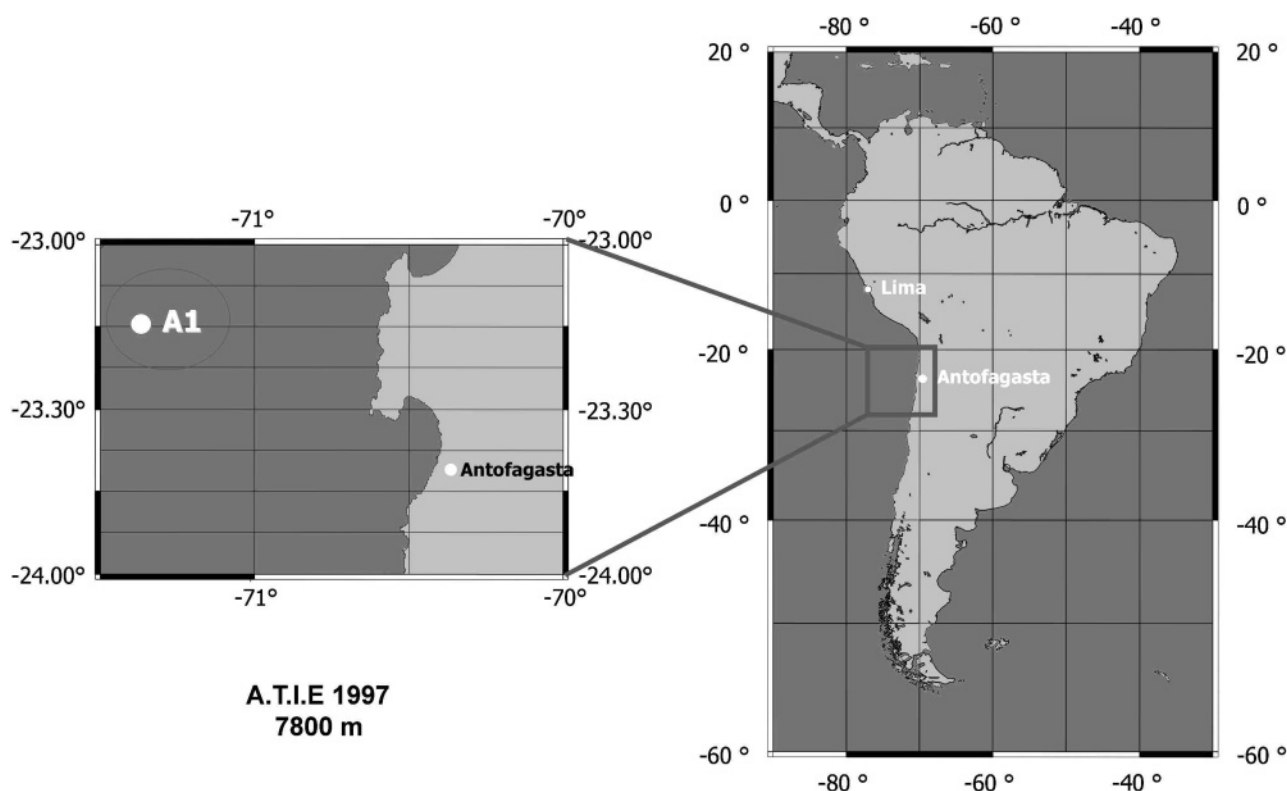


Fig. 1. Location map.

the other an elongate, three-chambered species resembling *Resigella* (Pl. 1, figs 2–3). Two other allogromiid species resembling *Nodellum* also occurred. One of them (Pl. 1, fig. 4) is a very distinctive needle-like form that is most similar to the genus *Chitinosiphon* Thalmann & Bermudez, 1954. Loeblich & Tappan (1987) regarded *Chitinosiphon* as a synonym of *Nodellum*, but we consider it to be a distinct genus on the basis of its slender morphology and pointed proloculum. The saccamminids were dominated by a single species with two apertures located at either end of the elliptical test. Flask-shaped saccamminids with a single aperture were represented by only two individuals.

Most of the soft-shelled foraminifera ranged in maximum dimension from 30 µm to 400 µm but a few *Nodellum*-like forms were larger (up to 720 µm) (Fig. 2). Agglutinated forms (saccamminids and psammosphaerids) dominated the lower end of the size spectrum (<120 µm), *Nodellum*- and *Resigella*-like

forms were largely responsible for a distinct peak around 120–160 µm, and the spherical Allogromiid sp. 1 dominated the larger-size classes.

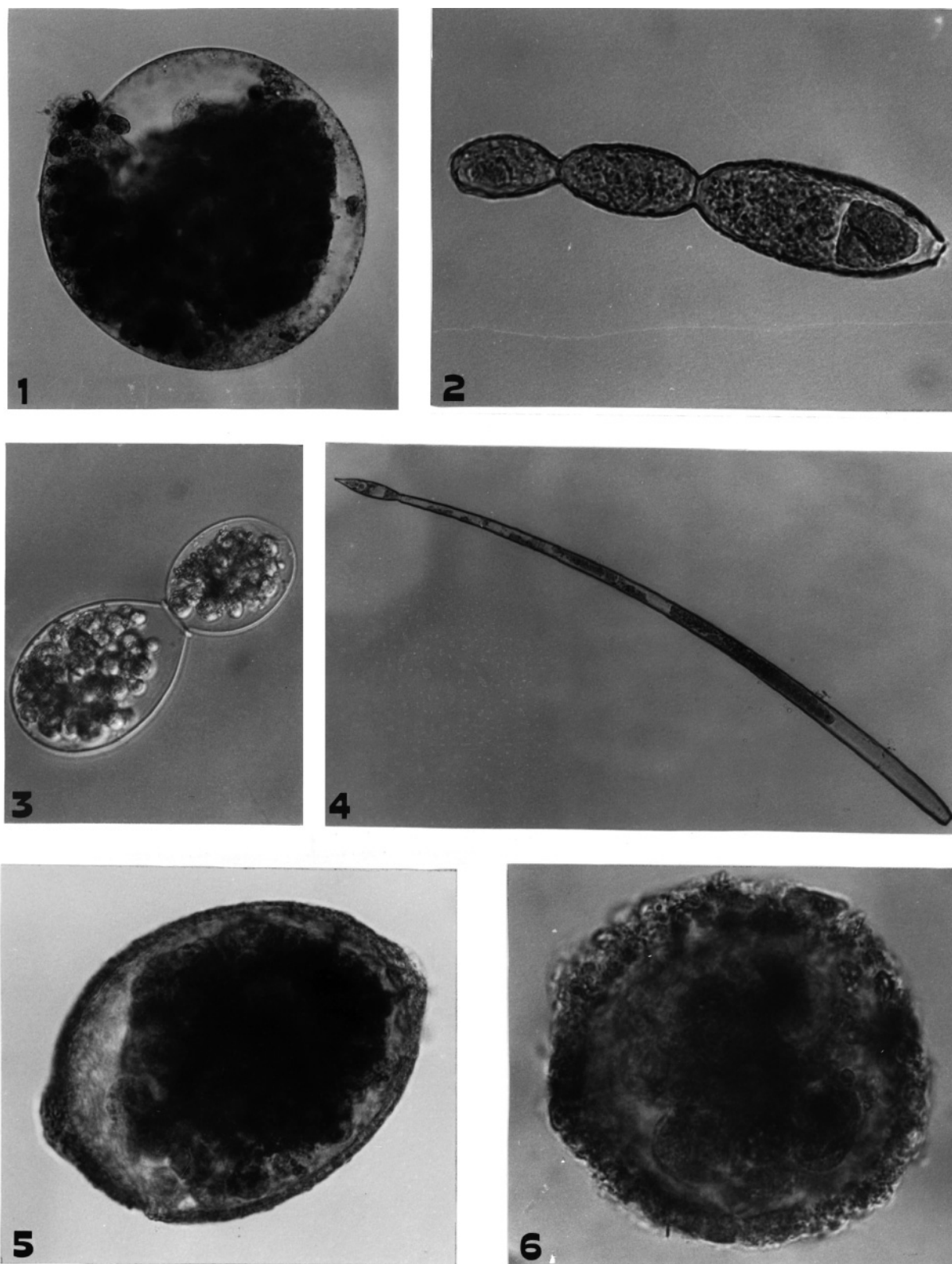
DISCUSSION

Because treatment with Ludox preferentially concentrates the light, soft-walled foraminifera, leaving the heavier species in the residue, the floated fraction of our sample contained only a few hard-shelled foraminifera (two specimens of *Lagenammina* sp.). Also, we cannot be confident that the allogromiids and saccamminids (Table 1) represent an unbiased sample of the original soft-shelled assemblage. Despite being semi-quantitative, our results are of considerable interest for several reasons.

- With the exception of a single *Nodellum*-like species (*Xenotheca elongata*) described from >9000 m water depth in the Kurile–Kamchatka Trench (Saidova, 1970), ours is the deepest record of organic-walled allogromiids and soft-shelled saccamminids from a marine habitat. The only other record of hadal allogromiids is from a 7198 m deep site in the Aleutian Trench where unspecified ‘allogromiids’ made up 41% of meiofaunal taxa (excluding other foraminifera) in the >297 µm fraction of a box-core sample (Jumars & Hessler, 1976). A recent report of agglutinated foraminifera from a 10924 m deep site in the Mariana Trench included only forms with rigid tests (Akimoto *et al.*, 2001).
- Tiny *Nodellum*- and *Resigella*-like forms represented almost 50% of the soft-shelled assemblage. Similar morphotypes occur widely at bathyal and abyssal depth (Gooday, 1996;

	Individuals		Species	
	Numbers	Percent	Numbers	Percent
Allogromiina	449	82.0	14	70.0
Saccamminidae				
Soft-shelled	61	11.0	2	10.0
Psammosphaeridae				
Soft-shelled	34	6.0	3	15.0
Other taxa	2	1.0	1	5.0
Total specimens	546		20	

Table 1. List of Rose Bengal-stained soft-shelled foraminifera from the Atacama Trench sample.



Explanation of Plate 1. Soft-shelled foraminifera from the Atacama Trench (except where indicated, specimens were photographed using normal illumination). **figs 1–4.** Organic-walled allogromiids: **1**, Allogromiid sp. 1 – spherical species with stercomata and protoplasm (diameter 340 μm); **2**, *Resigella*-like form (species 1) – elongate species with three chambers (note the area of cytoplasm with a nucleus near the aperture; length 200 μm); **3**, *Resigella*-like form (species 2) – tiny species with two chambers containing stercomata and a thin, transparent test wall (photographed using interference contrast; length 140 μm); **4**, very elongate form with a pointed proloculum, resembling the genus *Chitinosiphon* (length 720 μm). **fig. 5.** Saccamminid sp. 1 – agglutinated species with two apertures located at either end of the elliptical test which contains stercomata (length 160 μm). **fig. 6.** Psammospheerid sp. 2 – spherical agglutinated test without obvious apertures and containing stercomata (length 100 μm).

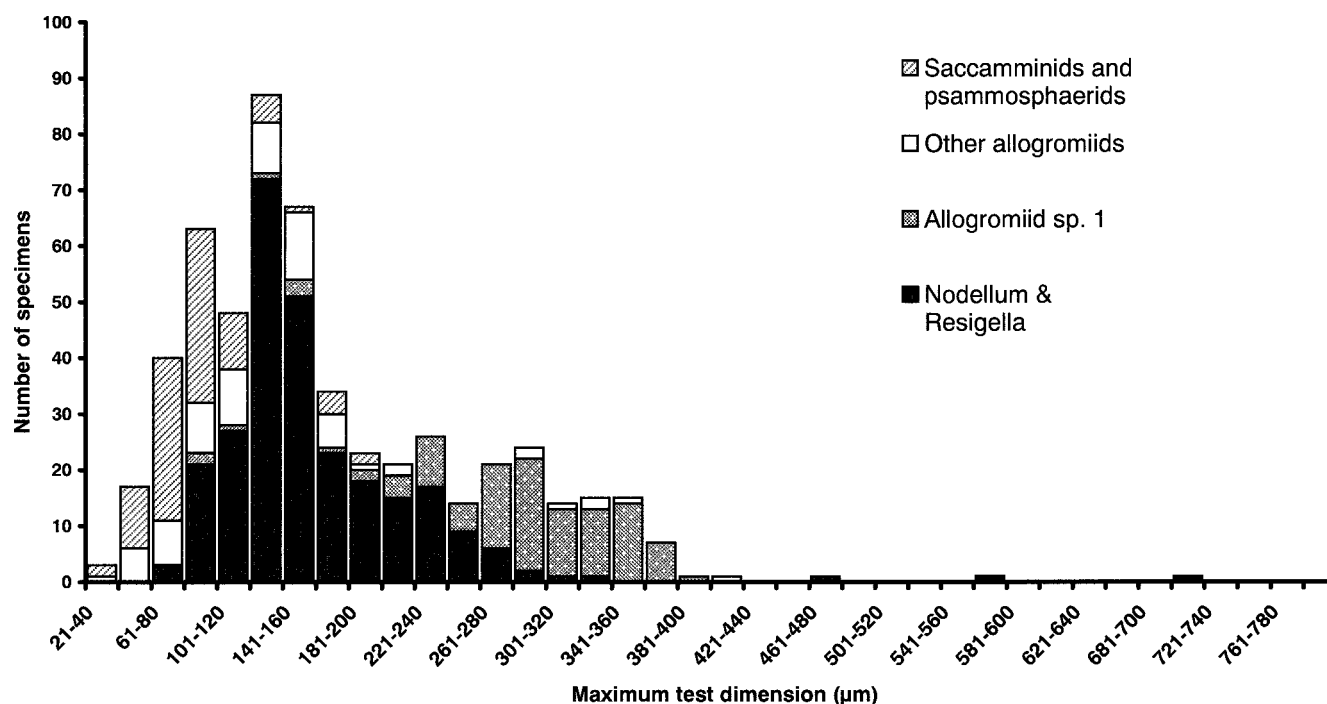


Fig. 2. Maximum test dimensions of all 'live' (Rose Bengal-stained) soft-shelled foraminifera from the Atacama Trench sample. Different components of the assemblage are indicated by different shading.

Gooday *et al.*, 1995, 2001), but usually they do not dominate the soft-shelled component of the foraminiferal fauna.

- Almost all the saccamminids belonged to a species with two apertures at opposite ends of an elliptical test. Flask-shaped forms with one aperture were very rare. At localities in the North Pacific, North Atlantic and Indian oceans, on the other hand, flask-shaped forms predominate over those with two apertures.

Our preliminary study provides further evidence for the widespread occurrence of soft-walled monothalamous foraminifera in marine habitats. Certain morphotypes, e.g. *Nodellum*- and *Resigella*-like allogromiids and saccamminids with two apertures, appear to be widely distributed in the deep sea. The very elongate, needle-shaped *Chitinosiphon*-like form that occurs in the Atacama Trench sample (Pl. 1, fig. 4) has close parallels in the bathyal North Atlantic (Gooday, 1986, fig. 1E). On the other hand, the two *Resigella*-like forms reported here (Pl. 1, figs 2–3) have not been observed elsewhere, although they resemble a two-chambered morphospecies from the North Atlantic and Pacific oceans (Gooday *et al.*, 1995, pl. III, fig. F). These *Resigella*-like species probably represent a new genus. Compared to the type species of *Resigella*, *R. moniliforme* (Resig, 1982), they are much smaller, have thinner walls and lack a distinctive secondary apertural structure at the proximal end of the test (Gooday, unpublished observations).

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