The chemical composition of a new “mica sandwich” foraminiferal species from the East Coast of Korea: *Capsammina crassa* sp. nov.

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We describe a new agglutinated monothalamous foraminiferal species, *Capsammina crassa* sp. nov., based on integrated observations of the test morphology and the chemical characteristics of materials composing the test. The new species was found at a depth of <60 m on the East coast of Korea. The test morphology is typical of the genus *Capsammina*, comprising two or more mica plates with a ring of finely agglutinated mineral grains sandwiched between them and surrounding the cell body. There is no distinct test aperture. Elemental analyses of the agglutinated grains revealed 15 different types of mineral grains of which quartz is the most abundant. The surface areas of grains exposed on fractured surfaces ranged from 1.6 to 7738 µm² and the large plate-like grains forming the upper and lower surfaces measured about 500 to 1200 µm (in one case 1550 µm) in width. The new species is morphologically similar to *C. patelliformis*, however the differences in size, distribution area and depth support that these two species are distinct. This discovery is the first record of the genus *Capsammina* from the North Pacific. Therefore, it extends the biodiversity and geographical distribution of the genus *Capsammina*, which has been reported only from the bathyal NE Atlantic. Our finding also suggests the possibility of additional discovery of monothalamous foraminifera from around Korea.
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Abstract
We describe a new agglutinated monothalamous foraminiferal species, *Capsammina crassa* sp. nov., based on integrated observations of the test morphology and the chemical characteristics of materials composing the test. The new species was found at a depth of <60 m on the East coast of Korea. The test morphology is typical of the genus *Capsammina*, comprising two or more mica plates with a ring of finely agglutinated mineral grains sandwiched between them and surrounding the cell body. There is no distinct test aperture. Elemental analyses of the agglutinated grains revealed 15 different types of mineral grains of which quartz is the most abundant. The surface areas of grains exposed on fractured surfaces ranged from 1.6 to 7738 µm² and the large plate-like grains forming the upper and lower surfaces measured about 500 to 1200 µm (in one case 1550 µm) in width. The new species is morphologically similar to *C. patelliformis*, however the differences in size, distribution area and depth support that these two species are distinct. This discovery is the first record of the genus *Capsammina* from the North Pacific. Therefore, it extends the biodiversity and geographical distribution of the genus *Capsammina*, which has been reported only from the bathyal NE Atlantic. Our finding also suggests the possibility of additional discovery of monothalamous foraminifera from around Korea.

Introduction
The genus *Capsammina*, and its type species *Capsammina patelliformis* Gooday, Aranda da Silva, Koho & Lecroq, 2010, were established by Gooday et al. (2010) based on samples collected at lower bathyal depths in the Nazaré Canyon, off Portugal. This distinctive agglutinated monothalamous foraminifera had been discovered a few years earlier in the same submarine canyon by Koho et al. (2007), who identified it as *Crithionina* sp. Morphologically, *Capsammina* is characterized by a test that lacks an obvious aperture and by two or more large, plate-like particles of mica forming the upper and lower surfaces and separated by a more or less circular ring of white, fine-grained agglutinated material. Phylogenetically, *C. patelliformis* belongs in a clade branching with several *Crithionina* species but was considered by Gooday et al. (2010) to be sufficiently distinct to justify the establishment of a new genus. Additionally, the same authors have suggested that the species *Psammosphaera bowmanni* Heron-Allen and Earland, 1912 may be transferred to *Capsammina* and there is the possibility that *P. bowmanni* may be a variant of *C. patelliformis* based on its use of mica flakes in the test construction and bathymetry. However, more sufficient evidences such as molecular data are required to support these assumptions.

A recent survey based on new and literature data estimated that a total of 818 benthic foraminiferal species, which belongs to 239 genera, 89 families and nine orders, currently inhabit the waters round the Korean peninsula (Kim et al., 2016). According to these data, of the orders belonging to the class Monothalamea, only Astrorhizida including seven genera and 11 species have been reported from Korea. The authors suggested that this figure might be an underestimate.
since samples from deeper waters, as well as monothalamids, had not been fully considered. Additionally, the middle to north part of the East/Japan Sea, off the Korean peninsula, has not been well studied in comparison with that of the West Coast (Yellow Sea), the South Sea, and the southern part of East/Japan Sea. Kim et al. (2016) concluded that further sampling in these understudied areas, as well as at greater depths, would certainly lead to an increase in the total known foraminiferal species diversity around the Korea peninsula. Support for this prediction came in May 2016 with the recognition of a new *Capsammina* species at a site off the eastern coast of Korea, only the second record of this genus outside the Iberian, Celtic and Scandinavian margins of western Europe. The purpose of the present paper is to describe this new species based on test morphology, including a detailed analysis of the chemical and mineral composition of the test.

Study area

The East/Japan Sea surrounds the Korean peninsula, Japanese archipelago and the Russian territory of the Asian continent (Fig. 1). This Sea has the characteristics of a semi-enclosed, marginal basin and is connected to the adjacent East China Sea, northwestern Pacific Ocean and Okhotsk Sea through four shallow straits, Korea (Tsushima), Tsugaru, La Perouse (Soya), and Tartar, which together have a maximum depth is about 130 m (Ozawa, 2003; Oba and Irino, 2012; Khim and Bahk, 2014). The waters of the East/Japan Sea increase sharply in depth from the coast (Yu et al., 2011), averaging approximately 1,500 m with a maximum depth of about 3,700 m (Choi et al., 2012). The eastern coast of the Korean peninsula is influenced by the North Korea Cold Current (NKCC) and the East Korea Warm Current (EKWC) (Fig. 1). The NKCC, characterized by cold and low salinity water, flows from north to south along the east coast of the Korean Peninsula. The EKWC breaks out from the Tsushima Current and characterized by a higher temperature and salinity. It also flows from the south to the north along the east coast of the Peninsula and merges with the NKCC at around 37° to 38° N latitude to form a subpolar Frontal Zone characterized by high productivity and rich biodiversity (Ashjian et al., 2005; Lee et al., 2016; Yoon et al., 2016). The East Sea water is represented by four water masses – Tsushima Surface Water, Tsushima Middle Water, North Korean Cold Water, East Sea Proper Water – defined by water temperature, salinity, dissolved oxygen and water depth (Yoon et al., 2007; Choi et al., 2012). These water masses are strongly influenced by seasonal variations of environmental factors; as a result, the intensity and range of current flow change dynamically and seasonally (Cho and Kim, 2000; Furey and Bower, 2005). A unique water mass structure is formed in summer due to the south-east monsoon wind, which intensifies the flow toward the north. In winter, the northwest monsoon wind causes the water flow to become stronger southwards (Yoon et al., 2007).

The new species was discovered on 21 May 2016 at station E08 of the ‘Korean National Marine Ecosystem survey’ (Fig. 1). The water depth at this site was 54 m. The bottom-water temperature was 5.03°C, lower than the mean value (5.85±3.34°C), while salinity was 33.99 PSU, close to the mean value (33.83±1.15 PSU) from the 23 east coast sampling stations of the ‘Korean
National Marine Ecosystem survey’ (KOEM, 2016). Since Station E08 is located within the mixing zone between NKCC and EKWC (Fig. 1), the temperature and salinity values were not significantly different from the mean values. At station E08 the grain size was dominated by silt-clay (5.57φ), close to the mean value (5.47φ±2.90), and the organic carbon content was 0.78%, lower than the mean value of 1.36±0.75% derived from all 23 stations (KOEM, 2016).

**Materials & Methods**

Sediments at station E08 were collected with a Van Veen grab. Immediately after sampling, the uppermost layer of sediment (ca. 1 cm) was stored in 250 ml bottles and treated with an ethanol-rose Bengal solution (2 g/L) to distinguish between living and dead foraminiferal specimens. In order to obtain additional specimens to analyze, the same station was sampled again on 16 May 2018 and sediment samples immediately frozen at -80°C.

In the laboratory, each sediment sample was divided into two aliquots, one for qualitative study and the other for quantitative study of benthic foraminifera. Each aliquot was placed in 50 ml bottles and dried in an oven at 40°C. After the sediments were completely dried, each aliquot was weighed. Aliquots for qualitative study were then gently washed through a 63-μm-mesh screen with tap water to remove clay, silt and any excess dye. The sieve residues were re-dried at 40°C and weighed to determine, by difference, the mud fraction. Benthic foraminifera were picked using a wet brush from the dried residues under an Olympus SZ40 dissecting microscope. Digital photographs of the new species were taken using an Olympus PEN Lite E-PL3 camera attached to an Olympus SZX12 dissecting microscope. Selected specimens were mounted on a stub, coated with Au-Pd and examined in a FEI Quanta 200 Scanning Electron Microscopy (SEM).

The maximum and minimum dimensions of 20 selected tests, including those of the mica plates and the agglutinated rings, were measured using the Axiovision Rel. 4.8. program. This program was also used to measure the maximum and minimum thickness of the agglutinated ring and the test in lateral view. In addition, the area of each mica plate was calculated using the ImageJ program.

Six individuals of the new species were selected for detailed analysis of the size distribution of the mineral grains and their chemical compositions. The size of the grains was evaluated by means of image analysis using the software Fidji and R on the flat surface that was exposed by the removal of one of the large plate-like mineral grains that define the shape of the test. After threshold adjustment and binarization of the image, grains were separated prior to being counted using watershed transformation tools (https://imagej.net/InteractiveWatershed#Watershedprinciple). The area of each grain was automatically determined and these data used as the basis for statistical treatment.

The methods used for the determination of the chemical composition of the mineral grains agglutinated in the foraminiferal tests largely followed the ones of Armynot du Châtelet et al. (2013b). All the observations were performed by an ESEM-EDS (Environmental Scanning Electron Microscope with an Energy-Dispersive Spectroscopy device FEI Quanta 200). This
technique is directly applicable on unpolished foraminiferal surface and allows us to determine
the grain shapes and to identify their mineralogical composition. The specimens were positioned
on stubs and carbon-coated to improve the quantification of chemical elements and to produce
quality pictures. The EDS data allow a quantification and qualification of the chemical elements
distributed within the surface of the agglutinated test (Armnout du Châtelet et al., 2013a, b,
2014). As a first step, the foraminiferal tests were visualized using secondary electrons to
determine their general shape, and then, as a second step, imaged for mapping selected chemical
elements, namely S, Al, S, Cl, Fe, I, Ti, Ca, Mg and K. The measurement and mapping were
carried out using a 20kV beam. An image analysis based on the chemical maps allows us to
characterize the mineral diversity whereas the mineral nature was constrained on point analyses'
results.

In order to visualize the distribution and elemental composition of the mineral grains, specimens
were reconstructed as 3D models from SEM images using SEM photogrammetric techniques
(Eulitz and Reiss, 2015). Specimens were glued at the end of a 50-µm-thick copper wire and
carbon coated. Within the chamber of the SEM, specimens were rotated to get surface
(backscattered electron) and chemical (secondary electron) images every 20°. Photogrammetric
reconstruction of 3D models was carried out using Visual SFM software.

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Systematic description

Supergroup Rhizaria Cavalier-Smith 2002
Phylum Foraminifera Cavalier-Smith 1998
Class Monothalamea Haekel, 1862
Order Astrorhizida Lankester, 1885
Genus Capsammina Gooday, Aranda da Silva, Koho & Lecroq, 2010

Capsammina crassa sp. nov. (Figs. 2–8, Tables 1–2)
urn:lsid:zoobank.org:act:712CADFE-DC11-4BA6-BDD4-A0EB1D80343D
**Etymology:** The name ‘crassa’ is derived from the Latin “crassus” meaning “fat, big, thick” referring large mica plate of new species.

**Diagnosis:** Relatively large species of *Capsamminina* characterized by compressed, sandwich-like construction with two flat mica plates attached to upper and lower sides of ring composed of finely agglutinated particles ring test surrounding cell body. Maximum size of test, including mica plates, up to ~2350 µm (occasionally more); maximum diameter of agglutinated ring up to ~1260 µm.

**Type material:** Holotype: Fig. S1. C, registration no. NIBRPR0000109500. Paratypes: five specimens, Figs. S2. A, B, D–F, registration nos. NIBRPR0000109501 – 5, additional 14 specimens, registration nos. NIBRPR0000109506 – 19. All specimens on micropaleontology slides from ‘Korean National Marine Ecosystem Survey’ Station E08; 37° 23’ 55.665” N, 129° 14’ 57.671” E, water depth 54 m, were collected on May 2016 and 2018. Holotype and paratypes are deposited in the National Institute of Biological Resources, Korea. The additional paratypes are deposited in the Marine Biodiversity Institute of Korea.

**Other examined material:** The mineral grain-size distribution and chemical composition of six specimens from the type locality were analyzed.

**Description:**

*Test structure.* The test is unilocular and lacks an obvious aperture. It is compressed with two irregularly-shaped, plate-like, mineral particles forming the flat top and bottom sides of test (Fig. 2). One of the plates is transparent and the other opaque, the transparent plate typically being the same or smaller in size than the opaque plate. The two plates are separated by a whitish, circular to broadly oval ring composed of agglutinated mineral particles that forms a wall enclosing the cell body. The constituent grains are quite variable in size but generally small, appearing finely granular at low magnifications. The coherence between the plates and the finely agglutinated test wall is relatively weak, so that these two components of the test can be separated fairly easily (Figs. 3 and 4). Examination of the underside of some plates exposed in this way reveals the presence of some smaller grains stuck onto the surfaces by very thin layers of organic material organized as an elongated network radiating from the center of the specimen towards the border (Fig. 4).

The maximum dimension of the test (in effect, the mica plates) is generally between 421 and 2348 µm (average of 956 ± 425 µm) and the minimum dimension between 243 and 992 µm (average of 549 ± 162). The agglutinated ring ranges from 443 to 1264 µm maximum dimension (average of 851 ± 197 µm) and the minimum dimension from 391 to 1032 µm (average of 656 ± 157 µm). It is 33.7 to 456 µm thick, with the thickness generally varying somewhat around the circumference of the ring. In detail, the maximum thickness of the agglutinated ring varies from 108 to 456 µm (average of 235 ± 85.8 µm), and the minimum thickness varies from 33.7 to 328 µm (average 111 ± 70.3 µm) (Table 1). The mica plate area of measured individuals varies from 83759 to 1250947 µm² (average of 410162 ± 210548 µm²) (Table 1). One paratype (Supplementary Fig. S1.A) is somewhat larger, the test including the mica plates measuring 1516
by 992 μm, and the more or less circular agglutinated ring, 994 by 891 μm in diameter and 67-175 μm thick. In side view, the mica plates are not always exactly parallel and so the width between two plates is not uniform. The maximum thickness in lateral view varies from 70.3 to 349 μm (average 177 ± 75.6 μm), and the minimum thickness varies from 30.7 to 183 μm (average 96.6 ± 48.5 μm) (Table 1). Five of the 20 measured individuals include three mica plates. Detailed test measurements for specimens with 2 and 3 mica plates are given in Tables S1 and S2 and summarized in Table 2. In general, specimens with 2 mica plates reach greater maximum dimensions than those with 3 plates.

Granulometry, chemistry and mineralogy of test particles. The grains constituting the wall (excluding the mica plates) have exposed areas ranging from 1.6 to 2000 μm² with a few grains up to 7700 μm² (Fig. 5), yielding a close to log-normal distribution (Shapiro-Wilk test on log of the grain size; p-value = 0.08) (Fig. 6). The fine grains represent 61% of the exposed surface when one of the mica plates is removed, and the remaining area is occupied by organic matter that cements the grains and secures them to the plates.

A total of 70 points analyses of the elemental composition of individual grains was carried out on the 6 specimens examined using ESEM-EDS (Table S3). The analyses included as wide a range of grains as possible, including the larger plate-like particles covering the specimens and much smaller ones constituting the main test wall. After equilibration of the chemical formulas of the mineral grains, 38 analyses correspond to clearly identified minerals, 26 correspond to minerals but with some doubt regarding their identification, 5 are of organic composition, and one grain yielded no chemical data. The following minerals were recognized (Figs. 5, 7 and 8): albite, biotite, calcite, dolomitic calcite, Fe(OH)$_3$, orthoclase, oxychlorite, phengite, plagioclase, quartz, rutile, sericite, sphene (titanite) and glass. Quartz grains are dominant in terms of number (Figs. 5A and 8B; blue-violet color). The large plate-like grains forming the upper and lower surfaces of the test are either sericite or phengite (members of the mica family). Some of the layers of sericite are altered to oxychlorite (Figs. 7 and 8).

The 3D reconstruction of the test and its chemical composition is shown in video S1 and S2. A complete 3D chemical reconstruction was not possible because of the large mica grains create shadows that limit the photons reaching the EDS detector (Video S3). Despite this, the different chemical composition of the two micas and the large-scale distribution of quartz grains are both clearly visible.

Cell body. The cell body is clearly visible through the transparent mica plate and occupies most (~85%) of the diameter of the lumen (Figs 3 and 7; Supplementary Fig. S1). SEM images reveal the presence of diatoms, presumably food items, within the cytoplasm (Fig. 7E).

Remarks: Capsammina patelliformis, the type species of genus Capsammina, was the only species belonging to the genus (Gooday et al., 2010). Capsammina patelliformis was described from the Portuguese margin in the NE Atlantic Ocean. It closely resembles the new species described here in having a distinctive, sandwich-like test that incorporates two large mica plates. The main morphological difference is the larger size of the new Korean species. The test,
including the mica plates, is up to 2348 µm in maximum dimension, while the inner ring of finely agglutinated particles is up to 126 µm in diameter. The corresponding dimensions for *C. patelliformis* are 640 µm and 260 µm, respectively. The width of the test as seen in side view is greater in *C. crassa*, up to 349 µm compared to a maximum of 80 µm in *C. patelliformis*, and the mica plates are thicker (compare Gooday et al., 2010, Pl. 4A with Fig. 2 of the present paper).

Finally, although Gooday et al. (2010) did not give precise measurements for the agglutinated grains constituting the inner part of the test of *C. patelliformis*, it appears from their published SEM images (e.g. Pl. 4, fig. A in Gooday et al., 2010) that these particles are somewhat larger than those we observed in the new species (Fig. 5B).

Unfortunately, it proved impossible to amplify DNA from any of our Korean specimens and so we are unable to confirm that *C. crassa* is genetically distinct from *C. patelliformis*. However, the fact that they originate from localities more than 10,000 kilometers apart, and at water depths differing by up to more than 3,000 meters, persuades us that the relatively minor differences noted above are sufficient to regard the Korean and NE Atlantic species as distinct. Gooday et al. (2010) assigned additional specimens found at shallower sites in the Nazaré (2847, 1160, 927 and 344 m depth) and Whittard (2436, 1389 m) canyons to *C. patelliformis*. However, at least some of these tended to have more three-dimensional tests (Gooday et al., 2011, Pl. 5) compared to those from the type locality. Since no genetic data were obtained from them, it is possible that these shallower specimens represent a different species. The comparison should therefore be between *C. crassa* and *C. patelliformis* from the type locality (3565 m depth) and nearby sites at similar depths (~3500 m) in the Nazaré canyon (Gooday et al., 2010, Table 1). *Capsammina crassa* sp. nov. occurs depths less than 100 m on the east coast of Korea, in the North Pacific Ocean. Since the East/Japan Sea is a semi-enclosed marginal sea, direct interactions between the two habitats are extremely unlikely.

The species *Psammospheara bowmanni* resembles *C. crassa* in having mica plates exposed on the test surface and no distinct aperture. *Psammospheara bowmanni* was originally described by Heron-Allen & Earland (1912) from the Firth of Forth (Scotland) and subsequently found elsewhere in Scotland (Murray et al., 2003) as well as Scandinavia (Höglund, 1947; Alve, 1990). There are also records from New Zealand waters (Höglund, 1947; Dawson, 1992) and Laptev Sea, part of the Arctic Ocean (Lukina, 2001). Both species also have similar bathymetric distributions; *P. bowmanni* occurs at 55–66 m water depth at its Scottish type locality, and *C. crassa* at 54 m depth. However, the syntype specimens illustrated by Gooday et al. (2010, Pl. 1) have polyhedral tests that are clearly different from the compressed tests of *C. crassa* and *C. patelliformis*. Additionally, the test of *P. bowmanni* includes a larger number of mica plates than either of these two species. Lastly, in *P. bowmanni*, sediment particles are agglutinated at the edges of mica flakes, and the size of agglutinated particles is much finer than *C. crassa* and *C. patelliformis*.

**Conclusions**
We have established *Capsammina crassa* sp. nov., a new monothalamous foraminiferal species from shallow water (<60 m) on the east coast of Korea. *Capsammina crassa* displays typical morphological characteristics of the genus, namely a sandwich-like structure in which 2 (occasionally 3) mica plates confine a ring-like formation composed of small mineral grains surrounding the cell body. Although it closely resembles the genotype *C. patelliformis* from the lower bathyal (~3500 m depth) Portuguese margin, differences in size and the wide geographical and bathymetric separation between the type localities support our conclusion that these two species are distinct. Unfortunately, we failed to obtain SSU rDNA sequences from *C. crassa*. Further efforts will be made to remedy this lack of genetic data in order to clarify the phylogenetic relationship between *C. crassa* and *C. patelliformis*, as well as between both these species and members of the *Crithionina*, a genus that resembles *Capsammina* in a number of respects.

This new species extends the geographical distribution of the genus *Capsammina* as well as our knowledge of foraminiferal biodiversity around the Korean peninsula. In particular, it increases the number of relatively robust monothalamid genera in the order Astrorhizida known from this region from 7 to 8, and the number of astrorhiziid species from 11 to 12 (Kim et al., 2016). The monothalamids were largely excluded from Kim et al. (2016)’s otherwise comprehensive survey of Korean foraminiferal diversity. It seems likely that future investigations will reveal additional species belonging to this group of ‘primitive’ foraminifera.

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Figure captions

Fig. 1. The map of study area and location of sampling site (station E08, 37° 23' 55.665" N, 129° 14' 57.671" E) marked with a star. Arrows indicate schematically the water currents of the East/Japan Sea (dark arrow: cold water current, light arrow: warm current). EKWC separates from TWC and flows northward. NKCC flows southward along the east coast of Korean Peninsula. EKWC = East Korea Warm Current. NKCC = North Korea Cold Current. TWC = Tsushima Warm Current. This map is made with Natural Earth. Free vector and raster map data @ naturalearthdata.com, and QGIS software v.2.18.18, a free and open source geographic information system. Water current information are from schematic map of surface current in the neighboring seas of Korea by Korea hydrographic and oceanographic agency.

Fig. 2. *Capsammina crassa* sp. nov. Secondary electron images of two specimens (A-D, E-F). The two large micas form the exterior of the test, largely obscuring the small grains that form the inner wall. Scale bars = 100 µm.

Fig. 3. *Capsammina crassa* sp. nov. Test of after removing one of the mica plates. The organic remains of the cell are visible in images B and D. Scale bars = 100 µm.

Fig. 4. *Capsammina crassa* sp. nov. Backscattered SEM image showing smaller grains arranged in radiating linear patterns, probably corresponding to pseudopodia and possibly associated with test construction. Scale bars = 100 µm.

Fig. 5. *Capsammina crassa* sp. nov. A. ESEM-EDS image showing elemental composition of the agglutinated grains; the following elements are distinguished: Si, Al, Fe, I, Ti, Ca, Mg, Na and K. B. Secondary electron image showing the density contrast between the quartz grains (a) mainly composed of Si (darker), the calcite grains (b) mainly composed of Ca (intermediate grey) and the oxides (c), in this case containing Fe composition (bright grains). Scale bars = 100 µm.

Fig. 6. Log-normal distribution of the grain size of the minerals attached to the mica plate.

Fig. 7. *Capsammina crassa* sp. nov. Secondary electron SEM of the test interior showing the underside of the large mica plate, the base of the finely-agglutinated inner wall, and the organic remains of the cell in the center (A-C). Three detailed images show the mineralogical diversity of the grains in the wall (D and F) and details of the cell body containing diatoms (E).

Fig. 8. *Capsammina crassa* sp. nov. ESEM-EDS color image of the interior of the specimen illustrated in Fig. 6. Individual mineral grains are identified based on point elemental analyses.

Tables

Table 1. Summary metrics (in µm) for the 20 measured individuals. max. = maximum, min. = minimum, stdev. = standard deviation.
Table 2. Summary metrics (in µm) for 5 individuals composed of three mica plates and 15 with two mica plates. max.= maximum, min.= minimum, stdev. = standard deviation.
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The two large micas form the exterior of the test, largely obscuring the small grains that form the inner wall. Scale bars = 100 µm.
Figure 3

*Capsammina crassa* sp. nov.

Test of after removing one of the mica plates. The organic remains of the cell are visible in images B and D. Scale bars = 100 µm.
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Log-normal distribution of the grain size of the minerals attached to the mica plate.
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|                  | min. | max. | average | stdev. |
|------------------|------|------|---------|--------|
| max. dimension   | 421  | 2348 | 956     | 425    |
| min. dimension   | 243  | 992  | 549     | 162    |
| max. ring dimension | 443  | 1264 | 851     | 197    |
| min. ring dimension | 391  | 1032 | 656     | 157    |
| max. ring thickness | 108  | 456  | 235     | 85.8   |
| min. ring thickness | 33.7 | 328  | 111     | 70.3   |
| plate area (µm²) | 83759 | 1250947 | 410162 | 210548 |
| max. lateral thickness | 70.3  | 349  | 177     | 75.6   |
| min. lateral thickness | 30.7  | 183  | 96.6    | 48.5   |
Table 2 (on next page)

Summary metrics (in µm) for 5 individuals composed of three mica plates and 15 with two mica plates. max.= maximum, min.= minimum, stdev. = standard deviation.
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|                          | min.        | max.        | average | stdev. |
|--------------------------|-------------|-------------|---------|--------|
| max. dimension           |             |             |         |        |
| three-plated (5 indiv.)  | 562         | 2285        | 938     | 447    |
| two-plated (15 indiv.)   | 421         | 2348        | 930     | 350    |
| min. dimension           |             |             |         |        |
| three-plated (5 indiv.)  | 259         | 736         | 478     | 154    |
| two-plated (15 indiv.)   | 243         | 992         | 585     | 157    |
| max. ring dimension      |             |             |         |        |
| three-plated (5 indiv.)  | 717         | 1083        | 938     | 147    |
| two-plated (15 indiv.)   | 443         | 1264        | 822     | 207    |
| min. ring dimension      |             |             |         |        |
| three-plated (5 indiv.)  | 621         | 919         | 705     | 122    |
| two-plated (15 indiv.)   | 391         | 1032        | 640     | 168    |
| max. ring thickness      |             |             |         |        |
| three-plated (5 indiv.)  | 189         | 386         | 274     | 83.9   |
| two-plated (15 indiv.)   | 108         | 456         | 222     | 85.2   |
| min. ring thickness      |             |             |         |        |
| three-plated (5 indiv.)  | 74.9        | 266         | 140     | 76.2   |
| two-plated (15 indiv.)   | 33.7        | 328         | 101     | 68.1   |
| plate area (µm²)         |             |             |         |        |
| three-plated (5 indiv.)  | 116997      | 690741      | 353254  | 191942 |
| two-plated (15 indiv.)   | 83759       | 1250947     | 438616  | 216707 |
| max. lateral thickness   |             |             |         |        |
| three-plated (5 indiv.)  | 104         | 290         | 191     | 67.6   |
| two-plated (15 indiv.)   | 70.3        | 349         | 172     | 79.8   |
| min. lateral thickness   |             |             |         |        |
| three-plated (5 indiv.)  | 30.7        | 105         | 61      | 27.7   |
| two-plated (15 indiv.)   | 35.9        | 183         | 109     | 48.6   |