



Revisiting the Galathea II expedition (1950–1952): Historical Significance and the Foraminiferal Collection at the Natural History Museum Denmark

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ABSTRACT

The Danish Galathea II expedition (1950–1952) was a major milestone in deep-sea exploration, but much of its micropaleontological material has remained unstudied. This paper provides an overview of the expedition and reviews the foraminiferal collection housed at the Natural History Museum Denmark (NHMD), focusing on its composition, curation history, and future research potential. The curated material is organized into four main components: (1) unprocessed and partly sorted sediment residues, (2) large, agglutinated foraminifera (i.e. Xenophyphorea, Komokiacea), (3) taxonomic slide sets prepared by Aksel Nørvang, and (4) assemblage slides mounted by Keith B. Lewis. Together, these include over 3 000 slides from around 200 sampling stations worldwide, spanning a wide range of marine environments from shallow coastal sites to deep-sea settings. Despite being stored for decades without further study, the collection remains in good condition and offers valuable data on foraminiferal diversity from the mid-20th century. This work aims to reintroduce this overlooked archive to the scientific community and highlight its relevance for taxonomy, paleoecology, and historical comparisons.

1. Introduction

Between the mid-nineteenth and mid-twentieth centuries, large scale oceanographic expeditions proliferated with three principal objectives: (1) charting seafloor topography, (2) collecting biological and geological specimens, and (3) improving navigation and communication routes. Initiated in the early 1800s and increasing markedly during the first decades of the twentieth century, these campaigns made use of existing shipping routes and administrative structures developed during European colonial periods, which provided logistical support and facilitated international collaboration. Some of the most well-known of these early expeditions include the *HMS Challenger* (1872–1876, United Kingdom; Gould, 2022), the *Galathea I* (1845–1847), *Dana I* and *II* (1920–1930, Denmark), *Discovery* (1925–1934, United Kingdom/USA (Reports, 1929; Morita and ZoBell, 1955; Schmidt, 1931), as well as mid-century programmes such as *Albatross* (1947–1948, Sweden) (Pettersson, 1949), the *Calypto* cruises (1951–1975, France), and the *Galathea II* (1950–1952, Denmark).

These missions provided the first systematic, basin-scale measurements of seafloor morphology and water-column structure. For the first time, scientists obtained reliable data on ocean temperatures at varying depths, shedding light on the dynamics of ocean currents. Stratigraphic profiles were determined thanks to sediment

cores collected during expeditions and allowed researchers to reconstruct the Earth's environmental history (Pettersson, 1949). By the late 1950s, these expeditions had enriched museum collections worldwide and significantly advanced our understanding of deep-sea ecosystems, their biodiversity, and the extreme conditions in which such a life exists.

The *Galathea II* expedition sampled both land and sea organisms, but its principal objective was deep-sea (hadal) sampling. Ocean floor sediments were taken at over 270 stations around the world, including 57 at depths over 5 000 m, being remarkable at the time. In contrast to the extensively studied macrofauna, laboratory processing subsequently generated micropaleontological material that remains largely unexamined despite its abundance and careful preparation.

In this work, we focus on the *Galathea II* micropaleontological collections housed at the Natural History Museum Denmark (NHMD) consisting of more than 3 000 mounted foraminiferal slides and residues from more than 200 stations. We discuss their historical context and lasting impact, emphasizing the importance of long-term preservation and curation. Such historical collections are increasingly recognized as invaluable archives for understanding global change as they provide baselines against which present and future environmental conditions can be assessed (e.g., Rillo et al., 2019; Miller and Jouet-Sarkany, 2025; Zarkogiannis et al., 2025).

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2. The Galathea II expedition

2.1. Preparations

The Galathea II expedition was part of a long-standing Danish tradition of scientific exploration. Earlier voyages, including the Arabia Expedition (1761–1767), the Galathea I expedition (1845–1847), numerous expeditions to Greenland and the Arctic (1880–1920), the Mortensen Pacific Expedition (1914–1916), and the Dana II expedition (1928–1930), laid the groundwork for this new task (Caspers, 1970). Building on these, the plan for the Galathea II expedition took shape after the second Dana expedition (1935), when biologist Johannes Schmidt, August Krogh, and colleagues mapped out a new expedition to determine what was living at the deepest seafloor locations (Seehusen, 1950). In the winter of 1949, with government and parliamentary approval, the *HMS Leith*, a former British frigate that had seen service in World War II was acquired for the expedition. The vessel measured 80 m in length (266 ft.), 11 m wide (34 ft.), and weighed 1 600 tons and was re-named *Galathea* (Fig. 1). Equipped with two steam turbines and twin propellers, it could reach a speed of 12 knots ensuring dependable performance throughout the journey, reaching maximum duration of 32 days without refueling (ZoBell and ZoBell, 1985).

The *Galathea* functioned as a fully equipped research laboratory with Carl Zeiss binocular microscopes, precision microtomes and full preservation facilities below decks (ZoBell and ZoBell, 1985). The bridge carried the finest 1950s navigation instruments including gyro-steering, Decca radar, and Kelvin-Hughes and Atlas echo-sounders for navigation and bathymetry (see Fig. 1 for a full inventory of onboard equipment and a schematic of the vessel's internal layout obtained from; Wolff, 1967). A cable system consisting of 15 km of hydrographic wire and a custom-tapered 12 km line, world's longest at the time, enabled precise deployment of nets and corers from the surface down to 10 700 m. This setup allowed deep-water trawls, Nansen bottle casts, and J-Z bacteriological sampling (Caspers, 1970). In addition, the sampling equipment included Agassiz sledges, reinforced double trawls, a Petersen grab, and piston corers that penetrated up to 24 m. These tools facilitated the

collection of benthic and demersal fauna and retrieved undisturbed sediment columns, yielding the first continuous stratigraphy of hadal clay (Larsen, 1968). Finally, precision echo-soundings mapped the Philippine, Kermadec and Tonga Trenches (Kiilerich, 1959), confirming Galathea II's role as a methodological reference for hadal research.

2.2. The expedition route

The expedition sailed on 15 October 1950. During the voyage, 775 stations, both on land and across shallow and deep waters, were sampled and documented (Bruun, 1957; Wolff, 1964) (Fig. 2). The first leg of the expedition traversed the eastern Atlantic Ocean, focusing on the West African coast. The expedition then proceeded along the eastern coast of Africa, exploring waters of Madagascar, Mozambique, Tanzania and Kenya, before moving into the northern Indian Ocean, to stations near Sri Lanka and India. It continued through the Strait of Malacca, paying special attention to Malaysian and Singaporean waters, and into the South China Sea. After this point, the expedition sampled at several stations across the Philippine and Indonesian regions. These locations were especially noteworthy because they included samples from the sea floor in some of the deepest ocean waters, including the Banda Trench in Indonesia, with a maximum depth of 7 300 m, and the Philippine Trench, which reaches depths of >10 500 m.

From these areas, the voyage continued to southern New Guinea and the Solomon Islands, then moved on to the waters around southeastern Australia and New Zealand. This region was also of particular interest for deep-sea studies, as it included areas over 10,000 m deep, such as the Kermadec and Tonga Trenches. After these stations, the expedition turned east, surveying the southwestern and central Pacific before reaching the Gulf of Panama. After surveying waters off Nicaragua, Costa Rica and Panama, the expedition crossed Caribbean waters at Puerto Rico.

On the return journey, the ship set an Atlantic course that included a short stop in the Bay of Biscay and in Plymouth, in the United Kingdom, before finally concluding in Danish waters nearly two years later, on June 29, 1952 (although no samples were taken in the UK or Danish waters). The expedition covered an impressive total of 63 700 nautical

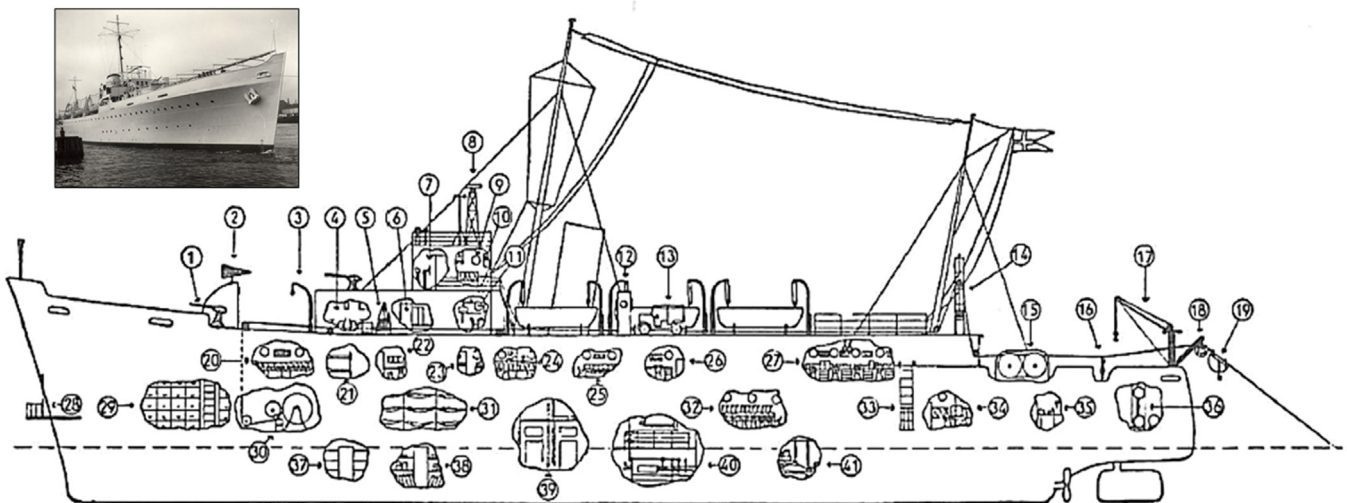


Fig. 1. The research vessel *Galathea* and schematic overview of its facilities. Top left: The *Galathea* docked at port during the 1950–1952 expedition. Main image: Schematic diagram showing the general arrangement of its scientific, technical, and living facilities, adapted from Danish Expeditions on the Seven Seas, Wolff, T. (1967). Key features included 1. salute gun; 2. fixed net for catching insects at sea; 3. starboard davit for taking bottom samples in shallow water; 4. reception tank; 5. hydrographic winch; 6. commanding officer's cabin; 7. wheel house; 8. radar; 9. chart house; 10. echo-sounder; 11. Wire-less room; 12. photographic tank for taking under-water films; 13. jeep; 14. accumulator for controlling tension of wire between drum and trawl winch; 16. dynamometer for checking tension of wire; 17. crane for heavy gear; 18. the large trawl gallows; 19. angle gauge fixed to wire while trawling; 20. crew's common room; 21. sick bay; 22. consultation cabin; 23. canteen; 24. petty officers' cabin; 25. petty officers' mess; 26. leader's cabin; 27. laboratory; 28. detachable harpooning platform; 29. hold for scientific collections; 30. drum for the trawl wire; 31. sleeping quarters; 32. officers' and scientists' mess; 33. detachable platform for lantern light fishing; 34. officers' and scientists' cabin; 35. dark room; 36. equipment store, including the large spheres for magnetic measurements; 37. cold store; 38. provisions; 39. stokehold; 40. engine room; 41. deep freezer for scientific use.

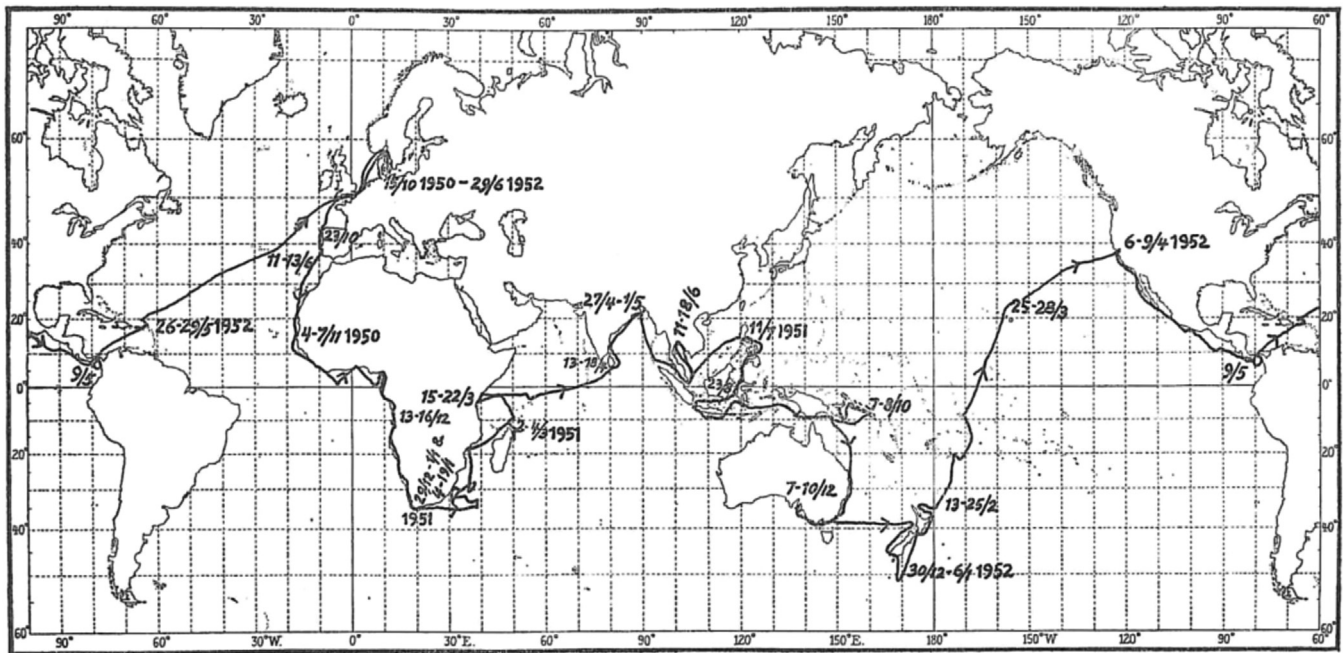


Fig. 2. Galathea II expedition route. Extracted from Danish expeditions of the seven seas, Wolff, T., (1967).

miles, approximately three times the Earth's equatorial circumference (Caspers, 1970).

2.3. Scientific findings and publications

The Galathea II expedition made a series of important methodological and scientific advances which, along with detailed station records and sampling data, have been published through the *Galathea Reports*. These volumes have since been digitized and are accessible through NHMD website (Website). Among the publications, the first coherent dataset on hadal communities can be found, including studies of biota from bacteria to vertebrates. Onboard incubations of suspended and sediment-bound microbial communities served to quantify primary production below 6 000 m and cultivate barophilic heterotrophs capable of metabolic activity under pressures exceeding 100 MPa (Morita and ZoBell, 1955, ZoBell and Morita, 1959). Trawls and corers recovered a range of taxa including siliceous sponges with atypical silica budgets (Nijampurkar and Somayajulu, 1970), trench-dwelling cnidarians (Carlgren, 1956; Kramp, 1956) and polychaetes (Holthe, 2000; Kirkegaard, 1956) sipunculan larvae (Cutler, 1977), the living monoplacophoran *Neopilina galathea* (Lemche and Wingstrand, 1959), and several crustacean groups such as giant isopods, caprellid amphipods, tanaids, and hermit crabs (Wolff, 1956; Wolff, 1961), all reported as adapted to high-pressure environments for the first time (Madsen, 1956; McCain, 1966). At higher trophic levels, ichthyological samplings recorded over thirty fish families, including ophidiids, ipnopids, and anglerfishes. A brotulid collected at 8370 m established a then-record for vertebrate depth (Nielsen, 1977). Additional captures included rare representatives of Cetomimidae, Barbourisiidae, Rondeletiidae (whalefishes), which expanded the documented diversity of deep-pelagic zone (Rofen, 1959).

In total, the expedition recovered over 300 kg of previously undescribed hadal fauna and helped establish a lasting baseline for biological, chemical, and geological processes in the deepest parts of the ocean. Most of the material remains curated at the NHMD and is accessible for research. Despite the broad taxonomic and ecological coverage discovered, hardly any published records have been found for foraminiferal assemblages. To date, only works on large, agglutinated forms, such as Xenophyophorea and Komokiacea, have been published (see

Section 3.2), while the majority of the microfaunal collection, although largely classified and evaluated at the genus or species level, remains unpublished and currently not easily accessible to the scientific community.

3. Foraminiferal collection

The NHMD's Galathea II foraminiferal collection is divided in four types of material: (1) a collection of sediment residues, comprising both washed and unwashed sediment fractions; (2) wet-preserved, large-bodied monothalamids including representatives of Komokiacea and the suborder Xenophyophoroidea, alongside histological slides of their tissues prepared with various staining techniques; (3) a collection of taxonomic foraminiferal slides; and (4) a second slide collection of foraminiferal assemblage slides.

At present, the sediments and wet specimens are partially catalogued in the internal NHMD database, while the slide collection is in the process of being digitized. For further information or access requests, enquiries may be directed to the second author, the curator responsible at the NHMD.

3.1. Sediment samples and residues

A substantial portion of the sediment material collected during the Galathea II expedition remains dry preserved at the NHMD. It includes both original unwashed and washed sediment residues which remain available for further analyses.

In total, the collection comprises more than 250 samples stored in a variety of formats, boxes, test tubes, vials, plastic bags, sealed bottles, and envelopes, reflecting a mix of historical and recent curatorial practices (Fig. 3). A significant portion of the materials had been on long-term loan to the foraminiferalogist Hans Jørgen Hansen (1939–2021) and was returned to the museum following his death. Upon return, the samples were transferred from their cardboard boxes to glass jars. Sub-samples preserved in smaller glass tubes were placed inside larger jars to ensure integrated storage and facilitate long-term curation. Most of these materials have original Galathea II labels from the Zoological Museum, prior to its integration into the NHMD. Among the material is a set of sealed sediment jars that have remained unopened since their original collection. These were presumably sealed wet, although most no



Fig. 3. Representative sediment sample set from the Galathea II Expedition. The main picture shown corresponds to materials from Station 471 (NHMD 923640, Location: Java Deep; 10°26'S, 114°15'E; 3080 m depth; collected on 10 September 1951), including the original label from the Zoological Museum (Copenhagen). The vials contain unwashed bulk sediment, coarse and fine washed fractions, and a small tube with unsorted biological fragments. Additional panels display similar material from other stations, station 569 (NHMD 923644, 38°44'S, 142°29'E, Great Australian Bight, 76 m); station 609 (NHMD 923688, 44°36'S, 167°51'E, Milford Sound, New Zealand, 139 m) and station 617 (NHMD 923685, 44°36'S, 167°50'E, Milford Sound, New Zealand, 139 m), illustrating the diversity of curation formats and sediment types preserved in the collection.

longer retain any liquid. In addition, a dedicated drawer at the NHMD holds 160 small glass vials containing sieved sediments, likely prepared for a micropaleontological study, though the associated project remains uncertain.

The sediment sample stations include West and East Africa, the western Indian Ocean, the South China Sea, the Philippine and Indonesian seas, the Australia-New Zealand region, and parts of the eastern Pacific. Notably, approximately 30 samples originate from trench environments at depths of 4000–10,000 m (e.g. Kermadec, Celebes, Sunda, Banda, and Philippine trenches) including both washed and unsorted material.

3.2. *Xenophyophores and Komokiacea: the work of Ole S. Tendal*

The few published foraminiferal studies from the Galathea II expedition material were carried out by Ole S. Tendal (1942–2020), who was curator at NHMD from 1987 to 2012. Tendal specialized in two morphologically complex and ecologically significant groups of deep-sea agglutinated foraminifers: Xenophyophorea and Komokiacea. He published

a comprehensive revision of the Xenophyophorea, based in Galathea II material, as part of his higher doctoral thesis (Tendal, 1972).

The NHMD currently houses a collection of over 80 ethanol-preserved specimens in jars, most from depths below 1 000 m (Fig. 4). The Xenophyophorea collection includes the genera *Hommogamina*, *Cerelasma*, *Galatheammina*, *Maudammina*, *Psammmina*, *Psammetta* (Psammionidae), *Sporadotrema* (Homotrematidae), *Stannoma*, and *Stannophyllum* (Stannomidae). Collected between 1950 and 1952, these specimens offer a rare pre-industrial baseline for deep-sea benthic communities. Their large, agglutinated tests retain information on sediment composition and barite incorporation (Gooday et al., 1992), key for tracing early mineral cycling (Tendal, 1972) prior to the onset of industrial-scale mining and bottom trawling.

Complementing the specimen jars, the NHMD also maintains a histological slide series (≈ 90) of Xenophyophore tissue preparations (Fig. 5). The tissues were processed using a range of staining protocols, including general cytological stains (e.g. Hematoxylin-Eosin, PAS-Mayer, Alcian Blue), connective tissue stains (e.g. Azan, Mallory, Millan), and special-



Fig. 4. Wet-preserved xenophyophore *Stannophyllum zonarium* from Galathea II station number 716 (NHMD 2009973, collected in Panamá (9°23'N, 89°32'W); 6 May 1952 at 3570 m). The specimen is curated in the micropaleontological collections of the Natural History Museum Denmark.



Fig. 5. Prepared microscope slides containing stained sections of various xenophyophore taxa from the Galathea II expedition collected at stations 231 (5020 m, Madagascar-Mombassa, 8°52'S, 49°25'E) and 238 (3980 m, off Kenya, 3°23'S, 44°04'E). The specimens include representatives of *Homogammina*, *Psammella*, and *Stannophyllum*, mounted with different staining techniques (e.g., eosin, toluidine blue, green, and hematoxylin). These slides are part of the micropaleontological collection at the NHMD.

Table 1

Holotype specimens of xenophyophore species described by Tendam (1972) based on Galathea II material. Each entry includes the original station number, sampling depth (in meters) and coordinates, and corresponding genus and species name. All specimens are preserved at the Natural History Museum Denmark.

Former Collection No.	NHMD No.	Station	Depth (m)	Coordinates	Genus	Species
Pro-000001	000110593	233	4 730	7°24'S, 48°24'E	<i>Psammella</i>	<i>arenocentrum</i>
Pro-000002	000110594	200	5 110	29°39'S, 37°01'E	<i>Moudammina</i>	<i>arenaria</i>
Pro-000004	000110596	192	3 430	32°00'S, 32°41'E	<i>Galatheammina</i>	<i>tetraedra</i>
Pro-000007	000110599	234	4 820	5°25'S, 47°09'E	<i>Cerelasma</i>	<i>massa</i>
Pro-000008	000110600	200	5 110	29°39'S, 37°01'E	<i>Stannophyllum</i>	<i>fragilis</i>
Pro-000009	000110601	232	4 930	9°03'S, 49°22'E	<i>Stannophyllum</i>	<i>indistinctum</i>
Pro-000010	000110602	231; 235	5 020	8°52'S, 49°25'E 4°47'S, 46°19'E	<i>Stannophyllum</i>	<i>mollum</i>

ized stains for lipids, iron deposits, and microbial presence (e.g. Luxol Fast Yellow, Fe-Pearl, Gram, Toluidine Blue).

Tendam's work formally recognized Xenophyophorea as a distinct subclass within foraminifera (Tendam, 1972). However, subsequent molecular studies demonstrated that xenophyophores belong within the Monothalamea Foraminifera (Pawlowski et al., 2003; Pawlowski et al.,

2013), a classification that has since been refined and is now widely adopted (Gooday et al., 2025). Tendam's 1972 monograph also provided the designation and description of seven new species, with holotype specimens collected during Galathea II expedition; representatives of these taxa are summarized in Table 1. In subsequent work, Tendam identified trophic interactions with the deep-sea mollusc *Neopilina galathea*,

based on the presence of foraminiferal fragments in gut contents and associated feeding traces (Tendal, 1985). Later studies refined the biogeographic distribution of xenophyophores using comparative data from Galathea II and other expeditions (Tendal, 1995). In collaboration with R.R. Hessler, Tendal also established Komokiacea as a new superfamily within Textulariina, introducing two new families and several new genera and species, partly based on eight Galathea II samples (Tendal and Hessler, 1977). The classification of Komokiacea was subsequently revised and the group is now considered as a suborder within Astrorhizida (Tavera-Martínez and Marchant, 2017; Hayward et al., 2025). These contributions were published in the Galathea reports and associated taxonomic monographs.

3.3. Taxonomic foraminiferal slides

The NHMD collections house nearly 3 000 single-species slides containing foraminiferal specimens sorted by species by Aksel Nørvang (1914–1968), who worked at the museum from 1958 to his early death in 1968. The specimens originate primarily from West African stations, with a smaller number of slides from East Africa, Asia and

Australasia. These foraminifera were originally intended for comparison with material from the Atlantide expedition (1945–1946), which also sampled the West African coast. However, the work was never published.

The West Africa subset, with approximately 2 800 slides (Fig. 6), can be organized into three principal offshore sectors: Off Congo River (material from 27 stations), the Lobito area (18 stations) and off the Kunene River (9 stations), with an additional smaller subset from the Kwanza area (Off Angola, 1 station) (Fig. 7). The collection contains 129 identified genera, offering a detailed view of the meso- to bathyal assemblages sampled during the Galathea II Expedition. A representative selection of the recorded genera is illustrated in Fig. 8, while Table 2 list common genera across the studied regions. Complete list of taxa can be found in supplementary material.

Genus-level comparison shows that the most frequently observed taxa across all four sectors include three benthic foraminifera genera (*Elphidium* (Montfort, 1808), *Cibicides* (Montfort, 1808), *Bolivina* (d'Orbigny, 1839)) and three planktic foraminifera genera (*Globigerinoides* (Cushman, 1927), *Globorotalia* (Cushman, 1927), *Hastigerina* (Thomson in Murray, 1876)) (Table 2). In contrast, the least consistently represented genera across sectors include four benthic taxa



Fig. 6. Selection of prepared taxonomical foraminiferal slides from the Galathea II expedition (1950–1952), illustrating the diversity and curation style of the NHMD foraminiferal archive. These examples come from West African stations and include both typed and handwritten labels by Aksel Nørvang and collaborators. Taxa represented here include *Nonionella atlantica* (Cushman, 1947; St. 84, 22–23 m), *Globorotalia crassaformis* (Galloway and Wissler, 1927; St. 71, 900 m), *Bolivina* (d'Orbigny, 1839; St. 71, 900 m), *Cancris auricula* (Fichtel and Moll, 1798; St. 86, 40 m), *Ptychomiliola separans* (Brady, 1881; St. 86, 40 m), and several additional genera such as *Nonion* spp. (Monfort, 1808; St. 88, 75 m), *Hastigerina siphonifera* (d'Orbigny, 1839; currently accepted as *Globigerinella siphonifera* (d'Orbigny, 1839); St. 86, 44 m) and *Virgulina mexicana* (Cushman, 1922; currently *Rutherfordoides mexicana* (Cushman, 1922; St. 72, 750 m). Each slide also includes specific location data with coordinates, date, and depth.

Table 2. A,B

Frequency matrix. The table shows the number of stations in which each foraminiferal genus was found across the four West Africa subregions: off Congo River, Lobito Area, off Kunene River and off Angola. Only genera with >10 total occurrences are included. Taxonomic identifications were conducted by Aksel Nørvang at the Natural History Museum Denmark, based on micropaleontological slides prepared after the Galathea II expedition. Taxonomic names have been checked and updated according to WoRMS (WoRMS, 2025).

A			Ammoniaculites	Ammonia	Ammoniscalaria	Amphicoryna	Bolivina	Bullimina	Cancris	Cassidulina	Cassidulinoides	Chilostomella	Cibicides	Cyclammina	Dentalina	Discobis	Eggerella	Ehrenbergina	Elphidium	Epistominella	Fissurina	Gavellinopsis	Globigerina	Globigerinoides	Globobulimina	Globoquadrima	Globorotalia	Gyroidinoides	Hastigerina	Hoeglundina	Lagena
Sub-Region	Station Number	Depth Range (m)																													
Off River Congo	69-96	20 - 1480	4	7	13	16	23	22	16	19	8	7	22	5	14	13	13	7	14	8	22	11	6	24	16	19	24	14	17	9	22
Lobito Area	105-125	20 - 4080	12	9	0	6	15	17	10	10	9	9	13	4	6	8	6	2	13	14	17	6	16	18	11	15	18	7	18	5	16
Off Kunene River	127-136	30 - 985	7	7	0	4	8	8	6	6	5	2	9	1	0	0	5	3	9	6	5	0	8	5	8	6	8	0	4	1	5
Off Angola	101	1000	1	0	0	0	1	1	0	1	1	1	1	1	0	0	0	0	0	1	0	0	0	1	1	1	1	0	1	0	0

B			Lenticulina	Margulinina	Miliculinella	Nonion	Nonionella	Oolina	Orbulina	Oridorsalis	Planorbulina	Planulina	Pseudogyroidina	Ptychomillia	Pullenia	Pulleniatina	Pyrgo	Quinqueloculina	Rectuvigerina	Reophax	Saccamina	Sigmolina	Siphonotextularia	Sphaeroidina	Sphaerocarinella	Spiroculina	Textularia	Trifarina	Uvigerina	Vauvilleria	Virgulina (=Fusenkovina)
Sub-Region	Station Number	Depth Range (m)																													
Off River Congo	69-96	20 - 1480	15	14	6	7	23	9	22	7	6	6	9	7	11	4	10	19	16	7	9	4	3	9	6	16	14	17	20	4	19
Lobito Area	105-125	20 - 4080	13	8	4	16	12	7	17	8	4	6	4	4	10	10	8	14	12	1	2	5	7	9	10	8	9	10	13	4	15
Off Kunene River	127-136	30 - 985	6	3	0	4	7	7	7	3	0	3	2	0	4	3	0	2	5	5	2	0	0	2	2	0	1	4	5	3	2
Off Angola	101	1000	1	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0	0	0	1	1	1

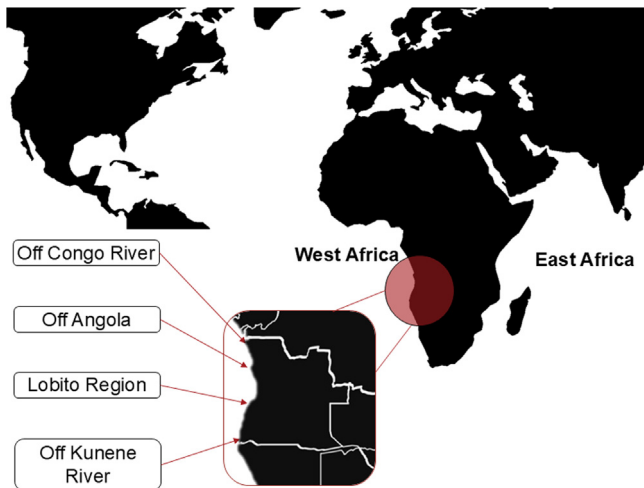


Fig. 7. Geographic distribution of over 90 sampling stations represented in the West African slides, highlighting key localities along the Angolan margin. Sampling areas defined in Aksel Nørvang slides, include off Congo River, off Angola, Lobito Region, and off Kunene River. Samples span a depth range of 20 to 4000m.

(*Hanzawaia* (Asano, 1944), *Robertina* (d’Orbigny, 1846), *Reusella* (Galloway, 1933), *Karriella* (Cushman, 1933)) and two planktonic taxa (*Pararotalia* (Le Calvez, 1949), *Hyalinea* (Hofker, 1951)) likely reflecting subtle environmental differences. Regarding lifestyle, the West African slides have a much higher number of benthic foraminifera, with only eight planktonic genera recorded, mainly *Globorotalia*, *Globigerinoides*, and *Orbulina* (d’Orbigny, 1839). Within the foraminifera, approximately 80 % of the genera recorded have hyaline tests. Porcelaneous and agglutinated test types are comparatively rare, each accounting for around 10 %.

Due to the number of sampling stations and the range of depths from which the West African foraminifera were collected, the material provides insight into depth-related distributions. Benthic generic richness is highest in bathyal stations (200–2 000 m), where 113 genera were recorded, compared to 97 genera on the continental shelf (0–200 m). The deepest stations of this collection showed 43 genera at abyssal depths (2 000–5 000 m), whereas no samples were available from the hadal zone (>5 000 m).

Although most slides originate from the West African region, additional slides prepared by Aksel Nørvang also cover East Africa (14 slides), the Philippines (29 slides), and the Australia-New Zealand region (62 slides).

3.4. Assemblage slides

This collection contains a set of approximately 150 slides prepared by Keith B. Lewis (1941–2025), based on work conducted at the New Zealand Oceanographic Institute (now part of Earth Sciences New Zealand). The material, which originates from 120 stations, substantially broadens the geographic and ecological scope of the collection. Accompanying the slides are Lewis’s original collections notes and taxonomic list, detailing the genera identified at each site and corresponding to the foraminifera found on respective slides (Fig. 9).

The Lewis slides are comprised of material from stations off East Africa; the western and northern Indian Ocean; the Strait of Malacca; the South China Sea; Philippine and Indonesian waters; the Australian and New Zealand region; parts of the southwest and central Pacific; and finally, the Gulf of Panama and the Caribbean Sea (Fig. 10). The following sections provide a regional overview of the most relevant taxonomic and environmental characteristics of the foraminiferal material of these areas. Unfortunately, information about Lewis’s sampling and picking methodology is currently unknown, and the foraminifera represented are likely derived from the larger size fractions of the sediment. Therefore, the data should be interpreted accordingly. A complete list of taxa can be found in Supplementary Material.

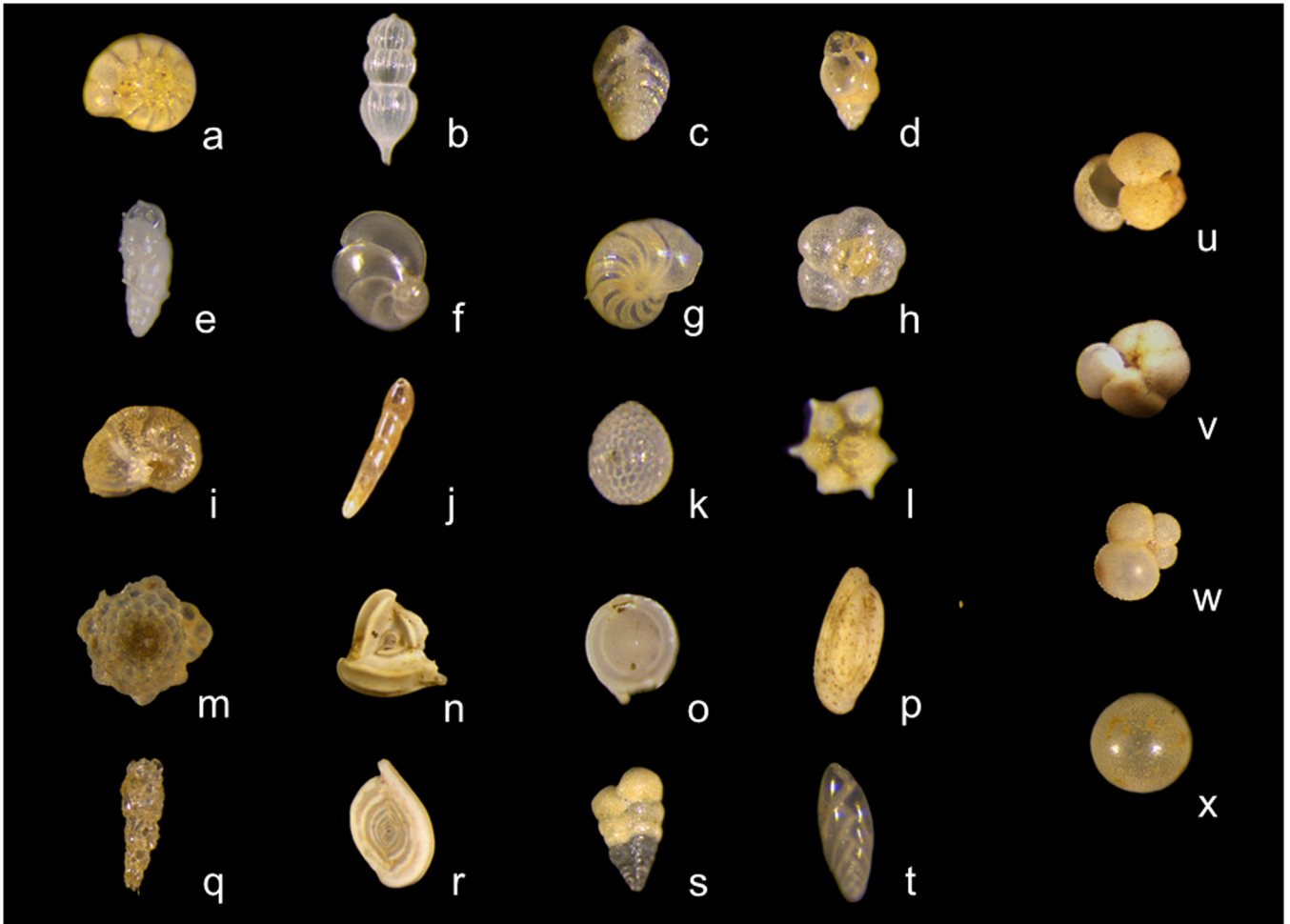


Fig. 8. Photographs of representative benthic and planktonic foraminifera from slides curated by the NHMD, based on material collected during the Galathea Expedition (1950–1952) off West Africa. Specimens are arranged alphabetically by genus within each group including station number and depth. Benthic foraminifera (a-t): a. *Ammonia* (Brünnich, 1771; St. 86, 40 m), b. *Amphycorina* (Claparède, 1864; St. 71, 900 m), c. *Bolivina* (d’Orbigny, 1839; St. 71, 900 m), d. *Bulimina* (d’Orbigny, 1826; St. 86, 40 m), e. *Buliminella* (Cushman, 1911; St. 101, 1000 m), f. *Cancris* (Montfort, 1808; St. 121, 27 m), g. *Cibicides* (Montfort, 1809; St. 86, 40 m), h. *Discorbis* (Lamarck, 1804; St. 121, 27 m), i. *Hanzawaia* (Asano, 1944; St. 86, 40 m), j. *Marginulina* (d’Orbigny, 1826; St. 71, 900 m), k. *Oolina* (d’Orbigny, 1839; St. 74, 285 m), l. *Pararotalia* (Le Calvez, 1949; St. 122, 200 m), m. *Planorbulina* (d’Orbigny, 1826; St. 79, 42 m), n. *Ptychomiliola* (Eimer and Fickert, 1899; St. 86, 40 m), o. *Pyrgo* (DeFrance, 1824; St. 71, 900 m), p. *Quinqueloculina* (d’Orbigny, 1826; St. 86, 40 m), q. *Reophax* (Montfort, 1808; St. 75, 205 m), r. *Spiroloculina* (d’Orbigny, 1826; St. 72, 750 m), s. *Textularia* (DeFrance, 1824; St. 121, 27 m), t. *Virgulina* (d’Orbigny, 1826; currently accepted as *Fursenkoina* (Loeblich & Tappan, 1961); St. 71, 900 m). Planktonic foraminifera (u-x): u. *Globigerinoides* (Cushman, 1927; St. 86, 40 m), v. *Globorotalia* (Cushman, 1927; St. 72, 750 m), w. *Hastigerina* (Thomson in Murray, 1876; St. 121, 27 m), x. *Orbulina* (d’Orbigny, 1839; St. 70, 1230 m).



Fig. 9. Examples of foraminiferal assemblage slides prepared by Keith B. Lewis, showing foraminifera individuals mounted together on a gridded format. Right. Cover of the original notebook, titled “*Rough Notes on Forams of Galathea Expedition*,” held at NHMD and including detailed taxonomic lists for each station.

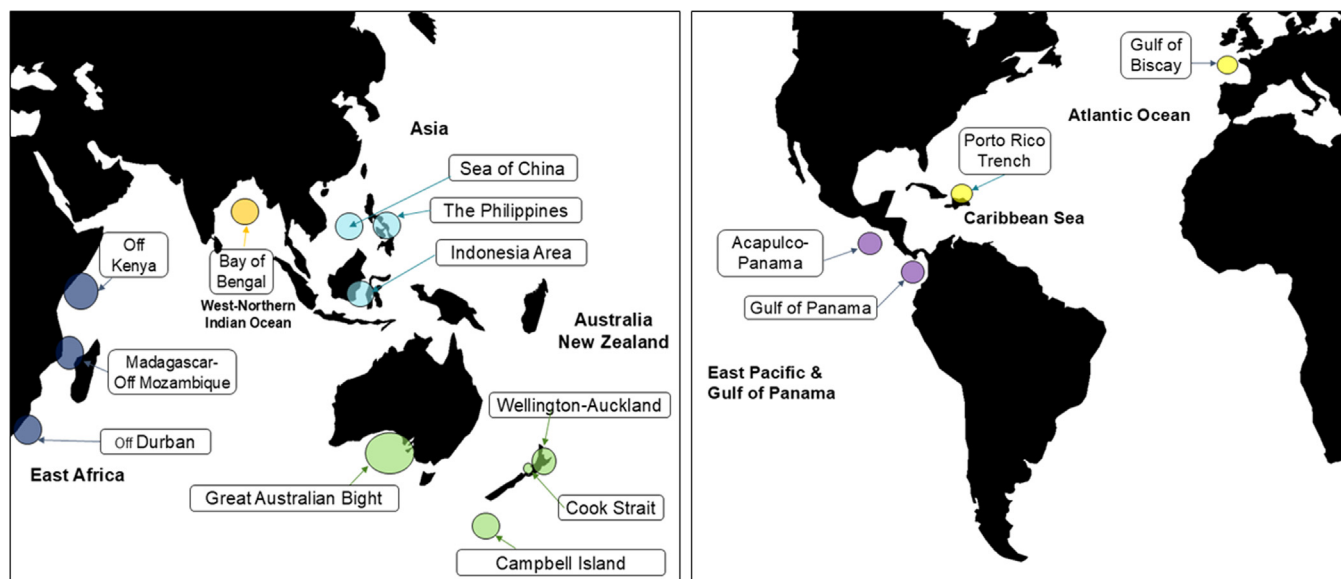


Fig. 10. Global distribution of sampling localities represented in the NHMD assemblage slide collection beyond West Africa. The map highlights key regions of foraminifera sorted by Keith B. Lewis, including East Africa, the northern Indian Ocean, Southeast Asia, Australia-New Zealand, the eastern Pacific, and the Caribbean-Atlantic.

3.5. East Africa and Indian Ocean

Despite being more limited in scale compared to West Africa, the East African and northern Indian Ocean slides reveal a distinct and coherent assemblage shaped by tropical shelf and slope conditions. The East African subset of the collection includes 23 stations (63 slides) sampled between South Africa and the Seychelles, yielding a total of 23 foraminiferal genera. Among these, *Lenticulina* (Lamarck, 1804), *Tholosina* (Rhumbler, 1895), and *Globocassidulina* (Voloshinova, 1960) are particularly well represented. A second, smaller group of slides from the northern Indian Ocean (2 slides), as well as from Malaysian and South China Sea waters (3 slides) showed 11 different genera with limited taxonomic similarity between stations

3.6. Southeast Asia and western Pacific

Moving eastward into Southeast Asia, the collection spans a remarkable range of depths, from coastal shallows to nearly 10 km below the ocean surface. In the Philippine area (6 slides) 10 genera were recorded, with *Amphistegina* (d'Orbigny, 1826) appearing repeatedly across stations. Just west of this region, the Indonesian series includes 15 stations (16 slides) reaching depths beyond 7000 m and records a more diverse assemblage of 54 genera. Among these, *Lenticulina*, *Bathysiphon* (Sars, 1872), and “*Nummulites*” (likely misidentified *Operculina* (d'Orbigny, 1826)) are the most frequently represented.

3.7. Australasia

In contrast, the Australia-New Zealand sector is represented by a far more extensive collection of slides. The Australian material comprises 20 stations (63 slides), primarily at depths shallower than 400 m, with a few deeper sites reaching approximately 4 500 m, distributed across the Coral and Tasman Seas and the Great Australian Bight. A total of 90 different genera were recorded, with *Polymorphina* (d'Orbigny, 1826), *Textularia* (Defrance, 1824), and *Triloculina* (d'Orbigny, 1826) being the most frequently occurring across stations. The New Zealand subset includes 38 stations (72 slides) spanning Milford Sound, Cook Strait, Perseverance Harbour (Campbell Island), and sites along the eastern coast of the North Island between Wellington and Auckland, covering a depth range of 0–1 000 m. Here, *Quinqueloculina* (d'Orbigny, 1826), *Lentic-*

ulina, and *Pyrgo* (Defrance, 1824) are the most consistently observed genera.

3.8. Central/Eastern Pacific and Atlantic

The final subset extends into more remote regions of the Pacific and Atlantic, including abyssal and bathyal settings. The South and Central Pacific subset (2 slides) includes two stations near the Kermadec Trench, which yielded 13 genera, with *Hoeglundina* (Brotzen, 1948) present in both samples. In the eastern Pacific and Gulf of Panama (11 slides), three stations located between 1 500, and 2 000 m depth produced 65 genera, with *Cyclammmina* (Brady, 1879), *Lenticulina*, and *Ammodiscus* (Reuss, 1862) among the most frequently observed. Similarly, three stations from the Caribbean Sea and western Atlantic (8 slides), all from depths greater than 1 000 m, revealed another 65 genera, with *Bulimina* (d'Orbigny, 1826), *Cibicides*, and *Uvigerina* (d'Orbigny, 1826) the most commonly occurring.

In addition to the sorted material, the collection includes over 30 supplementary slides containing as-yet unidentified taxa, many of them agglutinated foraminifera, representing all the regions mentioned above. Together, this body of material constitutes a geographically comprehensive archive with considerable potential for future taxonomic and paleoenvironmental research.

4. Legacy and future prospective

The micropaleontological collections from the Galathea II expedition represent an extraordinary scientific legacy that remains largely unexploited. Although, a considerable amount of preparation work has been carried out on the samples, especially those from West Africa, the work of both Nørvang and Lewis appears to have never been published. As a result, the collection has remained largely dormant for decades.

While most identified samples originate from the West African coast, their excellent state of preservation and well-documented context make them especially valuable as a reference dataset. The substantial amount of unprocessed material from the expedition, including >200 jars of bulk sediments and benthic residues with broader global coverage, may contain additional foraminiferal taxa. There is therefore large potential to expand the environmental and geographic scope of the original slide collection.

In addition to its historical and taxonomic significance, which includes pioneering incubations of microbial communities under extreme pressure, the first coherent biological dataset from hadal depths, and the discovery of several deep-sea taxa, the Galathea II foraminiferal collection holds considerable value for contemporary science. In the context of accelerating global change, historical collections like Galathea, provide a unique opportunity to detect long-term shifts in ocean chemistry, biodiversity, and sedimentary processes, especially given the wide range of depths and geographic regions represented. They are particularly relevant for the growing body of research comparing modern and past specimens (Yasuhara et al., 2020; Fox et al., 2020; Yasuhara and Hong, 2024), Improved curation, currently in process, and renewed scientific attention will be essential for unlocking their full research potential of the collection. The collection should therefore be seen not as a static archive, but as a resource with considerable potential for future interdisciplinary micropaleontological research.

Declaration of generative AI and AI-assisted technologies in the writing process

Authors declare that AI tools were used with the only aim of improving the readability and language of the final manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.revmic.2025.100872.

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