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Spatio-temporal distribution of American and oceanic benthic foraminifera of Anan

Abstract

This study deals with taxonomic consideration of three new genera: *Vaginulinoides* Anan[1] and *Vaginulinella* Anan[1] from Chile, and *Bolivinoidesella* Anan[2] from Pacific Ocean. Moreover, sixty one benthic foraminiferal species were erected by the present author from five localities in North, Central and South America (United States of America (USA), Mexico, Caribbean, Argentina and Chile) and some localities in Pacific and Atlantic Oceans. Nine species of the assemblage belong to Suborder Textulariina (~15%), 1 to Spirillinina (~1.5%), 2 to Miliolina (~3%), 25 to Lagenina (~41%) and 24 to Rotaliina (~39.5%). One of the recorded species is believed here to be new: *Vaginulinoides raoofi* Anan. Some of the recorded species present evolutionary foraminiferal lineages.

Keywords: paleontology, stratigraphy, lineage, America, Pacific Ocean, Atlantic Ocean

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Introduction

The present paper aims to highlight the paleontology, stratigraphy, paleogeography, and paleoenvironment of the 61 Campanian-Neogene benthic foraminiferal species which were originally erected by the present author from many different localities in North America (USA and Mexico), Central America (Caribbean), South America (Argentina and Chile), as well as Pacific and Atlantic Oceans (Figure 1).

Figure 1 Location map of the five American localities in North America (USA, Mexico), Central America (Caribbean), South America (Argentina, Chile), Pacific and Atlantic Oceans.

Systematic paleontology

The taxonomy of Loeblich & Tappan[3] is followed here. Sixty-one of the erected Campanian-Neogene small benthic foraminiferal species from five different localities in North, Central and South America are illustrated in the Plate (1). The recorded foraminiferal species belong to forty-three benthic genera: 27 species from Argentina (~44%), 16 from Chile (~26%), 5 from USA (~8%), 4 from Mexico (~6.5%), only one from Caribbean (~1.5%), and 8 from Atlantic and Pacific Oceans (~13%). Nine species (~15%) belong to Suborder Textulariina, 1 (~1.5%) to Spirillinina, 2 (~3%) to Miliolina, 25 (~41%) to Lagenina, and 24 (~39.5%) to Rotaliina. The paleontological record of it has an important value in the paleogeographic correlations with other Northern and Southern Tethyan localities.

Figure 2.

Order Foraminiferida Eichwald, 1830

I. Suborder Textulariina Delage & Hérouard, 1896

(1) *Bathysiphon usamai* Anan,[4] p. 43, pl. 1, Figure 2.7 (=*Bathysiphon* sp. - Kaminski & Huang,[5] p. 718, pl. 1, Figure 2.1). Eocene-Oligocene. Site 767, Leg 124, Celebes Sea, Pacific Ocean.

Remarks: This species has an elongate test, wall constructed of firmly cemented fine sand grains with smooth exterior. This species differs from the Bartonian-Priabonian species *Bathysiphon saidi* Anan by more elongated test, fine wall constructed of firmly cemented fine sands than coarse sand grains with rough exterior.

(2) *Orbulinelloides kaminskii* Anan,[4] p. 55, pl. 1, Figure 2.5 (=*Psammosphaera* sp. Kaminski & Huang,[5,6] p.178, pl. 1, Figure 2.11). Ypresian. Site 767, Celebes Sea, western Pacific.

Remarks: This species has coarsely to moderate agglutinated grains of the globular test, without elevated apertures on projection. It differs from the Bartonian-Priabonian *O. arabicus* Anan and Ypresian-Lutetian *O. sztrakosae* Anan in its less scattered large apertures without elevated on projection and older stratigraphic occurrence from Ypresian. It seems that this species represents the ancestor of that other species in Arabia and France, in *Orbulinelloides kaminskii*→ *O. sztrakosae* → *O. arabicus* lineage.

(3) *Reticulophragmium argentinica* Anan,[7] p. 1, pl. 1, Figure 2.4 (=*Reticulophragmium* sp. – Jannou,[8] p. 121, pl. 14, fig. N). Ypresian. Argentina.

Remarks: This species has agglutinated compressed planispirally enrolled test, tight biumbilicate, radial depressed sutures, and low arched aperture at the apertural face.

(4) *Parvigenerina chileana* Anan,[9] p. 38, pl. 1, Figure 2.3 (=*Textularia* sp. A. Finger,[10] p. 386, pl. 3, Figure 2.4). Miocene. Cheli.

Remarks: Its terminal aperture has a distinct thick neck.

(5) *Tritaxia argentinica* Anan,[9] p. 37, p. 1, Figure 2.2 (=*Tritaxia* sp. Jannou,[8] p. 104, pl. 15C). Eocene. Argentina.

Remarks: This species is closely related to Egyptian *Clavulinoides guayabalensis* (Cole) of Said & Kenawy (1956), but differs in longer test, more additional uniserial chambers, much sharper angles and more oblique sutures.

(6) *Gaudryina depressa* Anan,[11] p. 97, pl. 1, Figure 2.2 (=*Gaudryina* sp. of Alegret & Thomas,[12] p. 302, pl. 6, Figure 2.5). Paleocene. Mexico.

Remarks: This species differs from the *Gaudryina pyramidata* in its shorted test, and more broad rapidly biserial stage.

(7) *Gaudryina stasseni* Anan,[13] p. 33, pl. 1, Figure 2.4 (=*Gaudryina pyramidata* (Cushman) - Stassen et al,[14] p. 20, pl. 3, Figure 2.3). Thanetian. USA.

Remarks: The new species *G. stasseni* was described from the Late Thanetian of Bass River section, New Jersey of USA, and differs from Maastrichtian-Danian *G. pyramidata* by coarser agglutinated test.

(8) *Siphogaudryina chileana* Anan,[9] p. 37, pl. 1, Figure 2.1 (=*Gaudryina* sp. – Finger,[10] p. 381, pl. 2, Figure 2.13). Miocene. Chile.

Remarks: This species belongs to the genus *Siphogaudryina* due to its subterminal apertural face of last-formed chamber, instead of inner marginal aperture of genus *Gaudryina.*

(9) *Siphotextularia argentinica* Anan,[4] p. 38, pl. 1, Figure 2.5 **(=***Siphotextularia* sp. Jannou,[8] p. 121, Figure 2.14V). Eocene. Argentina.

Remarks: It is characterized by coarsely agglutinated wall, deeply depressed limbate structure, rounded aperture on the sutural position of the last two chambers, and limbate depressed sutures.

II. Suborder Spirillinina Delage & Hérouard, 1896

(10) *Patellina argentinica* Anan,[9] p. 39, pl. 1, Figure 2.14 (=*Patellina*? sp., Jannou,[8] p. 109, Figure 2.9 S-U). Eocene. Argentina.

Remarks: It has low conical planoconvex test, the proloculus followed by spiral crescentic undivided tubular chambers.

III. Suborder Miliolina Delage & Hérouard, 1896

(11) *Spiroloculina argentinica* Anan,[4] p. 38, pl.1, Figure 2.5 (=*Spiroloculina* sp. – Jannou,[8] Figure 2.15F). Eocene. Argentina.

Remarks: It has fusiform porcelaneous test in outline, chambers in one-half coil in length added in a single plane, and added rapidly pair-chambers of the test, sutures limbate depressed, aperture rounded at the open end of the final chamber with projecting neck.

(12) *Quinqueloculina argentinica* Anan,[4] p. 38, pl. 1, Figure 2.6 (=*Quinqueloculina* sp. – Jannou,[8] Figure 2.15H). Eocene. Argentina.

Remarks: It has smooth test, gradually added chambers but with an inflated medial chamber, and large round aperture with a single tooth.

IV. Suborder Lagenina Delage & Hérouard, 1896

(13) *Laevidentalina jannoui* Anan,[15] p. 36, pl. 1, Figure 2.1 (= *Dentalina* sp. – Jannou,[8] p. 177, Figure 2.6F). Ypresian. Argentina.

Remarks: It is characterized by an elongate and arcuate smooth test with gradually growing globular chambers, apiculate globular proloculus, flush sutures in the lower part but depressed in the upper part, aperture terminal. The Argentinian Ypresian *L. jannoui* is most probably evolved from the UAE Paleocene *L. hudae* Anan and considered here as the ancestor of the UAE Middle-Late Eocene *L. salimi* Anan (2009) in the *Laevidentalina hudae → L. jannoui → L. salimi* lineage.

(14) *Lagenoglandulina argentinica,*[15] p. 37, pl. 1, Figure 2.4 (=*Lagenoglandulina* sp. - Jannou et al.,[16] p. 36, pl. 3, Figure 2.3). Ypresian. Argentina.

Remarks: Test ovate and circular in section with few rectilinear chambers, which increase rapidly in breadth as added and strongly overlap the earlier chambers, sutures obscure in the early part, surface with finally scattered knobs, aperture terminal and radiate at the end of a short cylindrical neck. *L. argentinica* differs from the holotype *L. annulata* (Stache) by finally scattered knobs than the smooth surface.

(15) *Lingulina sliteri* Anan,[17] p. 54, pl. 1, Figure 2.2 (=*Lingulina* sp. – Sliter,[18] p. 75, pl. 9, Figure 2.11). Campanian. Mexico.

Remarks: It has arcuate longitudinal test, chambers gradually added, and the elongate slit terminal aperture is shifted to one side, not centered.

(16) *Tollmannia argentinica* Anan,[19] p. 3, pl. 1, Figure 2.6 (=*Lingulina* sp. – Jannou,[8] p. 101, Figure 2.6L). Ypresian. Argentina.

Remarks: The genus *Tollmannia* has globular-semi globular uniserial chambers with longitudinal costae or ribs, and circular in section. The *T. argentinica* is characterized by an elongated test, longitudinal ribs on the surface, and a rounded aperture with the small elevated neck. The Early Eocene *T. argentinica* most probably may develop into the youngest Miocene species *T. costata* (d'Orbigny), in *T. argentinica→ T. costata* lineage.

(17) *Tollmannia fingeri* Anan,[19] p. 42, pl. 1, Figure 2.4 (*Tollmannia costata* d'Orbigny – Finger,[10] p. 404, pl. 7, Figure 2.11). Miocene. Chile.

Remarks: This species is characterized by fine to coarse ornamented longitudinal ribs, but die out distally in the last chamber, slitlike terminal aperture, bordered by an elevated lip. It differs from *T. costata* in its die out distally rib in the last chamber, and without surface longitudinal ribs in the final globular chamber of *T. argentinica* than whole test.

(18) *Tristix sliteri* Anan,[17] p. 54, pl. 1, Figure 2.5 (=*Tristix* sp. – Sliter,[18] p. 80, pl. 10, Figure 2.15). Campanian. Mexico.

Remarks: This species has large test, ragged periphery, more opening terminal and radiate aperture. It resembles the type species *Tristix liasina* (Berthelin), but differs in its larger test, and larger numbers in chambers.

(19) *Leroyia argentinica* Anan,[19] p. 38, pl. 1, Figure 2.13 (= *Lenticulina* sp. – Jannou,[8] p. 179, Figure 2.6K). Ypresian. Argentina.

Remarks: This species has elongate smooth test with minute indistinct early coiled stage, later 7-10 uniserial inflated chambers increasing in length as added, sutures slightly depressed and oblique, peripheral margins rounded, aperture radiate extended at dorsal angle. The *L. argentinica* was evolved from Egyptian Thanetian-Ypresian *L. aegyptiaca* in the *L. aegyptiaca → L. argentinica* lineage.

(20) *Leticuzonaria argentinica* Anan,[19] p. 37, pl. 1, Figure 2.9 (= *Marginulina asperuliformis* Nuttall – Jannou,[8] p. 179, Figure 2.7P). Ypresian. Argentina.

Remarks: This species belongs here to the genus *Leticuzonaria* Anan,[19] not to *Marginulina* with the slightly coiled initial stage, followed by uniserial inflated chambers. The *Leticuzonaria argentinica* differs from the Egyptian *L. hodae* Anan by lacking a spinose surface, an elongated last chamber, protruding development of the aperture.

(21) *Palmula americana* Anan,[19] p. 38, pl. 1, Figure 2.11 (= *Palmula* cf. *magallanica* Todd & Kniker - Jannou,[8] p. 179, Figure 2.7B). Ypresian. Argentina.

Remarks: This species is characterized by a compressed palmate test with small coiled stage, and distinct slightly raised sutures. It differs from the holotype of the genus *Palmula sagittaria* Lea in its elongated larger test, smaller early planispirally stage, and slightly depressed sutures than raised.

(22) *Hemirobulina yehiai* Anan,[20] p. 56, pl. 1, Figure 2.41 (=*Pandaglandulina* sp. – Jannou,[8] Figure 2.7C). Lutetian. Argentina.

Remarks: This species is characterized by coiled early portion occupy about ¼ of the smooth test, while the last globose chamber occupies about ¾ of the test. This species is regarded here to be the ancestor of the UAE Paleocene *Hemirobulina olae* Anan and developed to the Egyptian Bartonian *H. bassiounii* Anan, in *Hemirobulina olae→ H. yehiai→ H. bassiounii* lineage.

(23) *Marginulina argentinica* Anan,[19] p. 36, pl. 1, Figure 2.15 (= *Lenticulina* sp. – Jannou,[8] p. 179, Figure 2.6U). Ypresian. Argentina.

Remarks: The test has slightly coiled initial stage, followed by inflated uniserial chambers ornamented by 20 longitudinal costae extended over the sutures, straight and slightly depressed sutures in the uniserial part, aperture terminal on a long neck. This species is regarded here to be the ancestor of the Middle-Late Eocene *M. costata* (Batsch) in the *M. argentinica → M. costata* lineage.

(24) *Vaginulinopsis argentinica* Anan,[15] p. 48, pl. 1, Figure 2.15 (=*Laevidentalina* sp. Jannou et al.,[16] p. 21, pl. 2, Figure 2.5). Ypresian. Argentina.

Remarks: The genus *Vaginulinopsis* has a planispirally enrolled and involute early stage with an apiculate proloculus, which does not exist in the genus *Laevidentalina*. *Vaginulinopsis argentinica* is characterized by elongate smooth curved test and circular in section, sutures depressed in the final three chambers, aperture terminal at the dorsal angle, and produced on a neck.

Genus *Vaginulinoides* Anan[1]

The genus is characterized by elongate perforate test; early stage planispirally enrolled and involute, later uncoiled and curved, laterally ovate to lenticular in section, sutures radial in the early stage, but straight horizontal and depressed in the uncoiled uniserial stage, surface ornamented by longitudinal ribs along the chambers, or along test crossing the sutures, aperture terminal radiate at the dorsal angle.

(25) *Vaginulinoides fingeri* Anan,[1] p. 92, pl. 4, Figure 2.4a (*Marginulina cubana* Palmer – Finger,[10] p. 416, pl. 10, Figure 2.10). Oligocene. Cuba, Chile.

Remarks: The *Vaginulinoides fingeri* Anan resemble the genus *Vaginulinopsis* Silvestri in main characters of the test, except the ornamented longitudinal ribs on the test surface of the former, than the smooth test in the latter, ornamented ribs are covered the chambers only without crossing the sutures.

(26) *Vaginulinoides raoofi* Anan, n. sp. (*Vaginulinopsis carinata*** (Silvestri) - Loeblich & Tappan,[3] p. 412, pl. 450, Figure 2.4, *non* figs. 1-3, 5, 6; *Vaginulinoides fingeri* Anan, 2023, p. 92, pl. 4, Figure 2.4b). Miocene. USA.

Etymology: after my late uncle Abd er Raoof Salim Anan.

Stratigraphic level: Miocene.

Diagnosis: This species is characterized by its ornamented ribs covered the chambers along the test crossing the sutures.

Remarks: It differs from *V. fingeri* Anan in its ornamented ribs cover all chambers crossing the sutures along the test.

Genus *Vaginulinella* Anan[1]

(27) *Vaginulinella fingeri* Anan,[1] p. 92, pl. 5, fig. 5a-c (=*Dentalina obliquecostata* (Stache) – Finger,[10] p. 400, Pl. 6, Figure 2.21).Miocene. Chile, Argentina, USA, Caribbean.

Remarks: The *Vaginulinella fingeri* Anan resemble the genus *Vaginulinoides* Anan in main characters of the test, except the rectilinear test than curved, ornamented longitudinal ribs along the test surface. *Vaginulinella fingeri* differs mainly from *Vaginulinoides fingeri* in its rectilinear test than curved test.

(28) *Vaginulina chilensis* Anan,[15] p. 49, pl. 1, Figure 2.19 (=*Astacolus mexicanus* (Nuttall) – Finger,[10] p. 415, pl. 9, Figure 2.19). Miocene. Chile, Mexico.

Remarks: This species has an elongate uniserial rectilinear laterally compressed perforated smooth test, septa thickened and elevated horizontal to slightly oblique, aperture radiate at the dorsal angle, and slightly produced. This new species differs from Egyptian Paleocene *V. boukharyi* Anan in its longer test, lesser and acuter width, with keel, and more elevated thick sutures. It seems that *V. boukharyi* most probably the root ancestor of *V. chilensis.*

(29) *Lagena chileana* Anan,[21] p. 59, pl. 1, Figure 2.6 (=*Lagena* sp. A – Finger,[10] p. 422, pl. 11, Figure 2.13). Miocene. Chile.

Remarks: The *Lagena chileana* is characterized by its globular test, ornamented by 20 faint longitudinal striae, and smooth collar around base of neck of the terminal aperture.

(30) *Lagena mainayefae* Anan,[21] p. 59, pl. 1, Figure 2.10 (=*Lagena* sp. B – Finger,[10] p. 422, pl. 11, Figure 2.14). Miocene. Chile.

Remarks: This new species is characterized by pyriform test, ornamented with 16 bladed longitudinal costae.

(31) *Lagena samarae* Anan,[21] p. 59, pl. 1, Figure 2.13 (=*Lagena* sp. C – Finger,[10] p. 422, pl. 11, Figure 2.15). Miocene. Chile.

Remarks: The *Lagena samarae* is characterized by pyriform test, with 16 bladed longitudinal costae. It differs from the Egyptian Paleocene-Early Eocene *Lagena rawdhae* Anan by about 16 of bladed longitudinal costae in the lower part of the test than about 30 longitudinal costae covering only about two-thirds of the lower part of the surface.

(32) *Reussoolina rustomi* Anan,[21] p. 60, pl. 1, Figure 2.28 (=*Reussoolina* cf. *apiculata* (Reuss) – Finger,[10] p. 424, pl. 11, Figure 2.26). Miocene. Chile.

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Remarks: The *Reussoolina rustomi* has deep radial grooves around the aperture, but lacks the apical protrusion that exists in the Maastrichtian-Miocene *R. apiculata*.

(33) *Ramulina fatemae* Anan,[20] p. 56, pl. 1, Figure 2.54 (=*Procerolagena*? sp. – Finger,[10] pl.11, Figure 2.20). Miocene. Chile.

Remarks: This species has elliptical ribbed ornamented form, with only two arms at each end, which differs from *R. shreifae* by elliptical ribbed ornamented test than smooth surface of the latter. The Eocene *Ramulina shreifae* Anan most probably the ancestor of the Miocene *Ramulina fatemae*, in *R. shreifae →R. fatemae* lineage.

(34) *Ramulina ismaili* Anan,[22] p. 2, Figure 2.2. 6b (*Ramulina* cf. *abscissa* of Bolli et al.[23]). Maastrichtian–Paleocene. Caribbean.

Remarks: It is characterized by its radiating triangular, tubular thick extinctions of the smooth chamber.

(35) *Ramulina morsii* Anan,[15] p. 39, pl. 1, Figure 2.20 (=*Ramulina* sp. – Jannou,[8] p. 104, Figure 2.7G). Ypresian. Argentina.

Remarks: This Ypresian species has radiating three triangular tubular thick extinctions of the chamber, and mainly with small projections surface. The *Ramulina morsii* n. sp. differs from the *R. ismaili* Anan by less thick elongate tapering tubular projection, and ornamented surface. The Maastrichtian–Paleocene *R. ismaili* most probably was developed to the Early Eocene *R. morsii* in its ornamented globular body and thicker elongated tapering three tubular arms, in that *R. ismaili → R. morsii* lineage.

(36) *Ramulina plummerae* Anan,[22] p. 5, Figure 2.3 (*Ramulina globulifera* Brady – Plummer,[24] p. 174, pl. 11, Figure 2.15b (*non* Figure 2.15a). Maastrichtian-Lutetian. USA.

Remarks: This species has a globular chamber, somewhat hispid, and bears four branch stoloniferous tubes around the

periphery and also another two central arms of the chamber. *Ramulina plummerae* differs from *R. globulifera* by its less hispid elliptical chamber with non-perpendicular four arms.

(37) *Ramulina subornata* Anan,[19] p. 39, pl. 1, Figure 2.18 (= *Ramulina* sp. cf. *globulifera* Brady – Jannou,[8] p. 104, Figure 2.7F). Ypresian. Argentina.

Remarks: This species has a globular chamber with sixth rounded spinose projections with numerous radiate tubular processes, surface is smooth, not ornate. *Ramulina subornata* differs from the American *R. ornata* Cushman by its smooth surface, not spinose projections on the surface, and 6 homogeneous distributions of the arms.

V. Suborder Rotaliina Delage & Hérouard, 1896

(38) *Brizalina argentinica* Anan,[21] p. 38, pl. 1, Figure 2.7 (=*Brizalina* sp. – Jannou,[8] p.105, Figure 2.7P). Miocene. Argentina.

Remarks: It is characterized by its narrow imperforate longitudinal costae.

(39) *Bolivinoidesella ameeri* Anan,[25] p. 46, pl. 1, Figure 2.7 (=*Bolivina huneri* Howe – D'haenens *et al.,*[26] p. 18, pl. 1, fig. 4. Ypresian. Bay of Biscay, NE Atlantic

Remarks: Test biserial series, chamber walls are calcareous and finely perforate, cylindrical shape and oval in cross-section with a subrounded initial portion, but rounded apertural end, slightly inflated chambers, sutures that are mostly obscured by surface ornamentation and ornamented by a pattern of anastomosing costae extending to all test. This species differs from the other species *Bolivinoidesella salimi* Anan in its cylindrical shape than pyriform shape.

(40) *Bolivinoidesella hudae* Anan,[25] p. 46, pl. 1, Figure 2.4 (=*Bolivina huneri* Howe - Miller & Katz,[27] p. 118, pl. 1, Figure 2.7. Oligocene-Middle Miocene. Site 563, North Atlantic, between N. America and W. Africa.

Remarks. Test elongate, wall ornamented with numerous delicate finely perforate, periphery broadly rounded, sides nearly parallel, sutures distinct inspite to the irregularly anastomosing costae surface ornamentation, aperture a wide semi-rounded extending from the base of the last chamber into the apertural face. This species differs from the other members of the genus *Bolivinoidesella* by its distinct depressed sutures all over the test, inspite to the irregularly anastomosing costae surface ornamentation along the most test. This Oligocene-Middle Miocene species may develop from the Eocene *Bolivinoidesella olae* Anan.

(41) *Bolivinoidesella karimae* Anan,[25] p. 44, pl. 1, Figure 2.2 (=*Bolivinoides decoratus* – Alegret & Thomas,[28] p. 13, pl. 1, Figure 2.2). Maastrichtian-Danian. ODP 1262, Walvis Ridge, south Atlantic Ocean.

Remarks. Test large elongate large biserial test, tapering initial test, nearly triangular in outline, chambers nearly globular increasing rapidly as added, surface indistinct due to the surface ornamentation with wrinkles or irregularly anastomosing costae in the most part of the test extending to all but the last chambers of the test, aperture basal, narrow opening extending from the base of the last chamber. This species with irregularly anastomosing costae, differs from *Bolivinoides decoratus* (Jones) with 4–5 loosely connected, longitudinal, broad, irregular costae extensions on each chamber merging into ornamental lobes.

(42) *Bolivinoidesella olae* Anan,[25] p. 45, pl. 1, Figure 2.3 (=*Bolivina huneri* Howe – D'haenens et al.*,*[26] p. 18, pl. 1, Figure 2.4). Ypresian. OSDP Site 401, Bay of Biscay-NE Atlantic.

Remarks: Test calcareous and finely perforated, elongate biserial series with nearly parallel sides; slightly and oval in cross-section with a subrounded initial portion, and a rounded apertural end, slightly inflated chambers, sutures are mostly obscured by surface ornamentation of anastomosing costae extending to all but the last chambers of the test. aperture is a loop-shaped opening, extending from the base of the last chamber. The cylindrical test of the Ypresian *Bolivinoidesella olae* differs from the nearly triangular outline of the Paleocene new species *B. karimae* with nearly tapering initial portion of the test. *Bolivinoidesella karimae* may evolve to the younger species *B. olae.*

(43) *Bolivinoidesella pacifica* Anan,[2] p. 44, pl. 1, Figure 2.1 (=*Bolivinoides* sp. - Alegret & Thomas,[29] p. 109, pl. 1, Figure 2.9). Maastrichtian-Danian. ODP 198, Shatsky Rise, Site 1210, Pacific Ocean.

Remarks: It is characterized by its finely perforate calcareous wall, elongate large biserial test, chambers nearly globular increasing rapidly as added, surface ornamented with wrinkles or irregularly anastomosing costae, periphery broadly rounded, sutures obscured in the lower part of the test, but slightly depressed in the upper part, narrow opening basal aperture. This species is characterized by elongate test, wrinkled ornamented surface and anastomosing costae than rhomboidal test with longitudinal costae may bifurcate distally as in the genus *Bolivinoides*.

(44) *Bolivinoidesella salimi* Anan,[25] p. 46, pl. 1, Figure 2.6 (=*Bolivina huneri* Howe - Alegret & Thomas,[29] p. 108, pl. 1, Figure 2.12). Maastrichtian-Danian. ODP 198, Shatsky Rise, Site 1210, Pacific Ocean.

Remarks: Test biserial series, chamber walls are calcareous and finely perforate, pyriform shape and oval in cross-section with a subrounded initial portion, but rounded apertural end, slightly inflated chambers, sutures that are mostly obscured by surface ornamentation and ornamented by a pattern of anastomosing costae extending to all test. This species is characterized by a pattern of anastomosing costae surface ornamentation extending to all pyriform test.

(45) *Buliminelloides argentinica* Anan,[30] p., pl. 1, Figure 2.6 (=*Bulimina* sp. aff. *fueguina* – Jannou,[8] p. 106, Figure 2.8N). Ypresian. Argentina.

Remarks: This species is distinguished by irregular cone-shape triserial test, ornamentation with irregular longitudinal costae wrinkles ornamentation from the initial rounded end to the base of the last whorl chambers, while the final chambers show unornamented wrinkles, nearly smooth and imperforated, aperture large and rounded at the face of the last chamber.

(46) *Orthokarstenia striata* Anan,[31] p. 72, pl. 1, Figure 2.19 (=*Siphogenerinoides* sp. aff. *elegantus* (Plummer) – Jannou,[8] Figure 2.8.C). Ypresian. Argentina.

Remarks: This species is characterized by its longitudinal striae all over the test, but with indistinct and regularly longitudinal striation in the test. The Early Eocene species *O. striata* Anan differs from the Paleocene-Early Eocene *O. eleganta* (Plummer) by its striated surface, which may evolved from it from the Maastrichtian *O. esnehensis*→ Paleocene-Ypresian *O. eleganta* → Ypresian *O. striata* lineage.

(47) *Rectuvigerina argentinica* Anan,[19] p. 39, pl. 1, Figure 2.24 (= *Stilostomella* sp. - Jannou et al.,[16] p. 42, pl. 3, Figure 2.19). Ypresian. Argentina.

Remarks: This species has elongate and slightly arcuate hyaline test, small involute triserial early stage followed by elongata uniserial stage, gradually grow globular to discoidal chambers, short ribs at the base of the chambers, proloculus globular but not apiculate, sutures depressed in later stage, aperture terminal on neck with a phialine lip.

(48) *Ellipsoglandulina argentinica* Anan,[32] p. 46, pl. 1, Figure 2.10 (=*Ellipsoglandulina* sp. – Jannou,[8] p. 189, Figure 2.12 O). Ypresian. Argentina.

Remarks: This species has uniserial smooth elongate test with circular in section, strongly overlapping chambers increase rapidly in size but the final two chambers comprising up the test length, sutures horizontal and depressed, aperture terminal and semilunate. The *Ellipsoglandulina argentinica* differs from the Egyptian Early Eocene *E. arafati* in its only two final overlapped tests, than more number of chambers which rapidly increased as added.

(49) *Pleurostomella plummerae* Anan,[33] p. 176, pl. 2, Figure 2.17 (=*Pleurostomella alternans* Plummer [34], p. 69, pl. 4, fig. 2b (*non* fig. 2a). Paleocene. USA.

Remarks: This species is distinguished by its short test than the other species of the genus and oval aperture.

(50) *Pleurostomella abedi* Anan,[32] p. 46, pl. 1, Figure 2.11 (=*Pleurostomella* sp. – Jannou,[8] pl. 12, figs. M-N). Ypresian. Argentina.

Remarks: This species has more width and shorter length than another species of the genus, aperture terminal, with projecting hood partially obstructed by two triangular teeth.

(51) *Valvulineria nabilae* Anan,[32] p. 46, pl. 1, Figure 2.12 (=*Valvulineria* sp. – Jannou,[8] p. 109, pl. 10, figs. A D). Ypresian. Argentina.

Remarks: This species has low trochospiral coil smooth test, few inflated and rapidly enlarging chambers per whorl, final chamber occupying about one-half the umbilical side and closed the umbilicus, aperture a broad umbilical opening at the base of the apertural face, sutures gently curved.

(52) *Woodella jawdati* Anan,[31,34] p. 74, pl. 1, Figure 2.32 (=*Elphidium* sp. – Jannou,[8] Figure 2.11S). Ypresian. Argentina.

Remarks: This species has trochospiral planoconvex test, 6-7 angular inflated centrally and peripherally chambers in the final whorls, sutures straight radial depressed, periphery angular, aperture a low interiomarginal equatorial arch at the base of the apertural face. This species is considered the second recorded of the genus in the western hemisphere, which recorded for the first time from Pakistan in the eastern hemisphere.

(53) *Planulina chileana* Anan,[9] p. 38, pl. 1, Figure 2.9 (=*Cibicides* sp. – Finger,[10] p. 458, pl. 21, Figure 2.1). Miocene. Chile.

Remarks: This species has small, low trochospiral test, two whorls with nine to ten broad low arched chambers in the final whorl, sutures limbate curved back at the peripheral keeled margin, aperture an equatorial-interiomarginal arch with narrow imperforate bordering lip and extending somewhat onto the umbilical side.

(54) *Cibicidoides chilensis* Anan,[35] p. 1, pl. 1, Figure 2.3 **(=***Cibicidoides* sp. – Finger,[10] p.457, pl. 19, Figure 2.7). Miocene. Chile.

Remarks: This species has low trochospiral compressed test, coarsely punctate, 10 chambers in last whorl, oblique and slightly curved limbate sutures connected to bluntly round peripheral carina. This species differs from the other members of the genus by its coarsely punctate surface, curved limbate sutures, and bluntly rounded periphery.

(55) *Cibicides chileana* Anan,[9] p. 38, pl. 1, Figure 2.9 (=*Cibicides* sp. – Finger,[10] p. 458, pl. 21, Figure 2.1). Miocene. Chile.

Remarks: It is characterized by its perforated test, faint periphery keel, and arched aperture with lip.

(56) *Falsocibicides chileana* Anan,[9] p. 39, pl. 1, Figure 2.10 (=*Falsocibicides* sp. – Finger,[10] p. 460, pl. 21, Figure 2.2). Miocene. Chile.

Remarks: This species has highly lobulate periphery, wide rounded umbilicate area, and large elongate aperture along the aperture face.

(57) *Pullenia argentinica* Anan,[9] p. 39, pl. 1, Figure 2.11 (=*Pullenia* sp. – Jannou,[8] p. 114, Figure 2.13E-F). Ypresian. Argentina.

Remarks: This species is characterized by its 8 chambers in the last whorl with some deep umbilicus, semi-compressed test, semi-lobate periphery, narrow slit aperture with faint lip extending over the periphery at the base of apertural face.

(58) *Globorotalites mexicana* Anan,[35] p. 100, pl. 1, Figure 2.16 (=*Globorotalites* sp. A - Alegret & Thomas,[12] p. 302, pl. 6, fig. 6). Paleocene. Mexico.

Remarks: This species is characterized by its closed umbilicus with 9 chambers in the last whorl than wide umbilicus with 8 chambers of the Egyptian Maastrichtian *Globorotalites conicus* (Carsey).

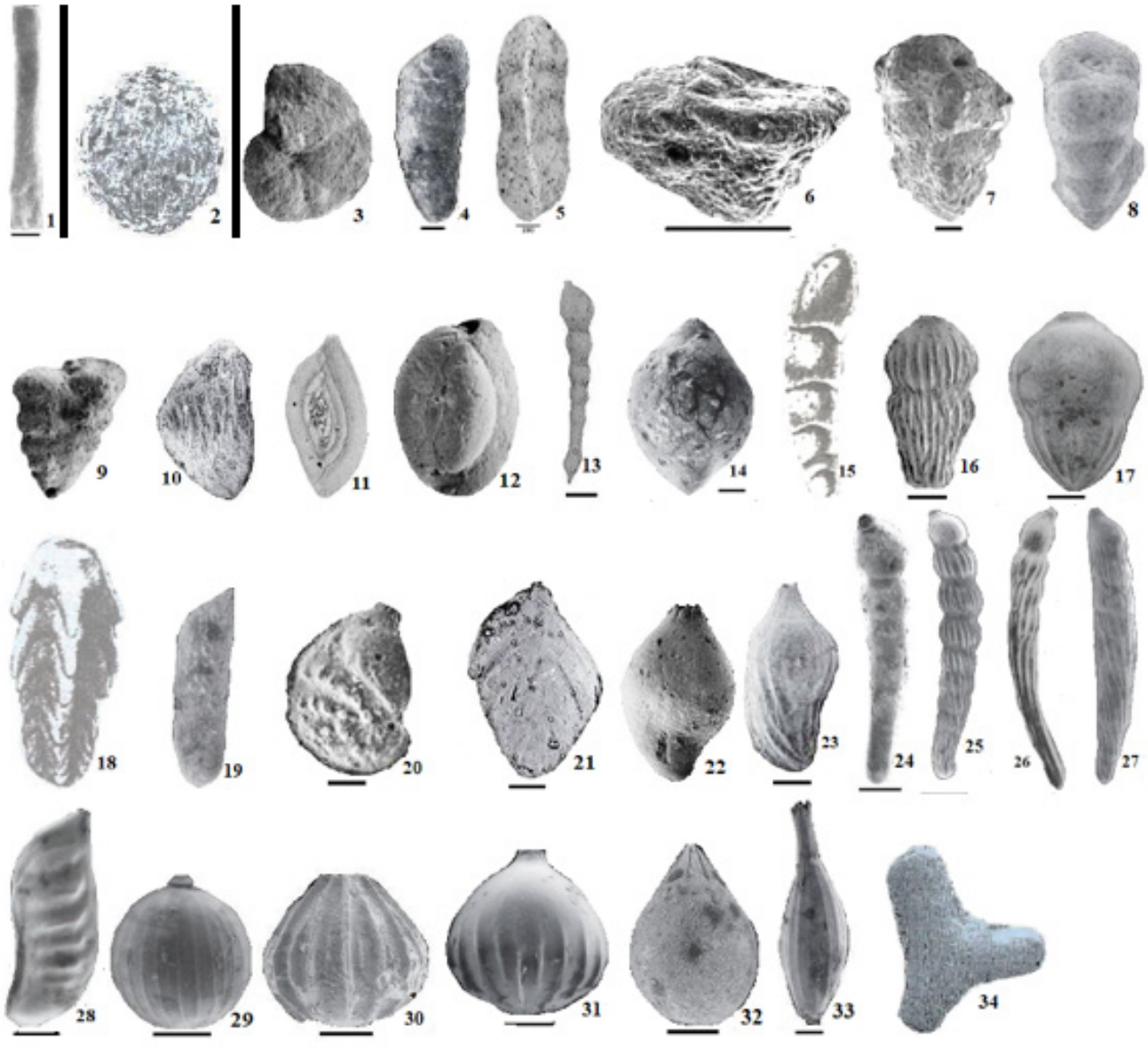
(59) *Gyroidina chileana* Anan,[9] p. 39, pl. 1, Figure 2.13 (=*Gyroidina* sp. – Finger,[10] p. 114, pl. 23, Figure 2.8). Miocene. Chile.

Remarks: This species differs from the other members of the genus *Gyroidina* by slightly concave spiral side but slightly depressed umbilicus, without limbate sutures.

(60) *Buccella argentinica* Anan,[9] p. 39, pl. 1, Figure 2.12 (=*Buccella* sp., Jannou,[8] p. 114, Figure 2.9C, D). Ypresian. Argentina.

Remarks: This species has an interiomarginal aperture at midway between umbilicus and periphery, but without covered umbilical granules.

(61) *Pararotalia loeblichi* Anan,[36] p. 24, pl. 2, Figure 2.10 (=*Pararotalia* sp. Loeblich & Tappan,[37] p. 21, pl. 5, Figure 2.3). Miocene. USA.



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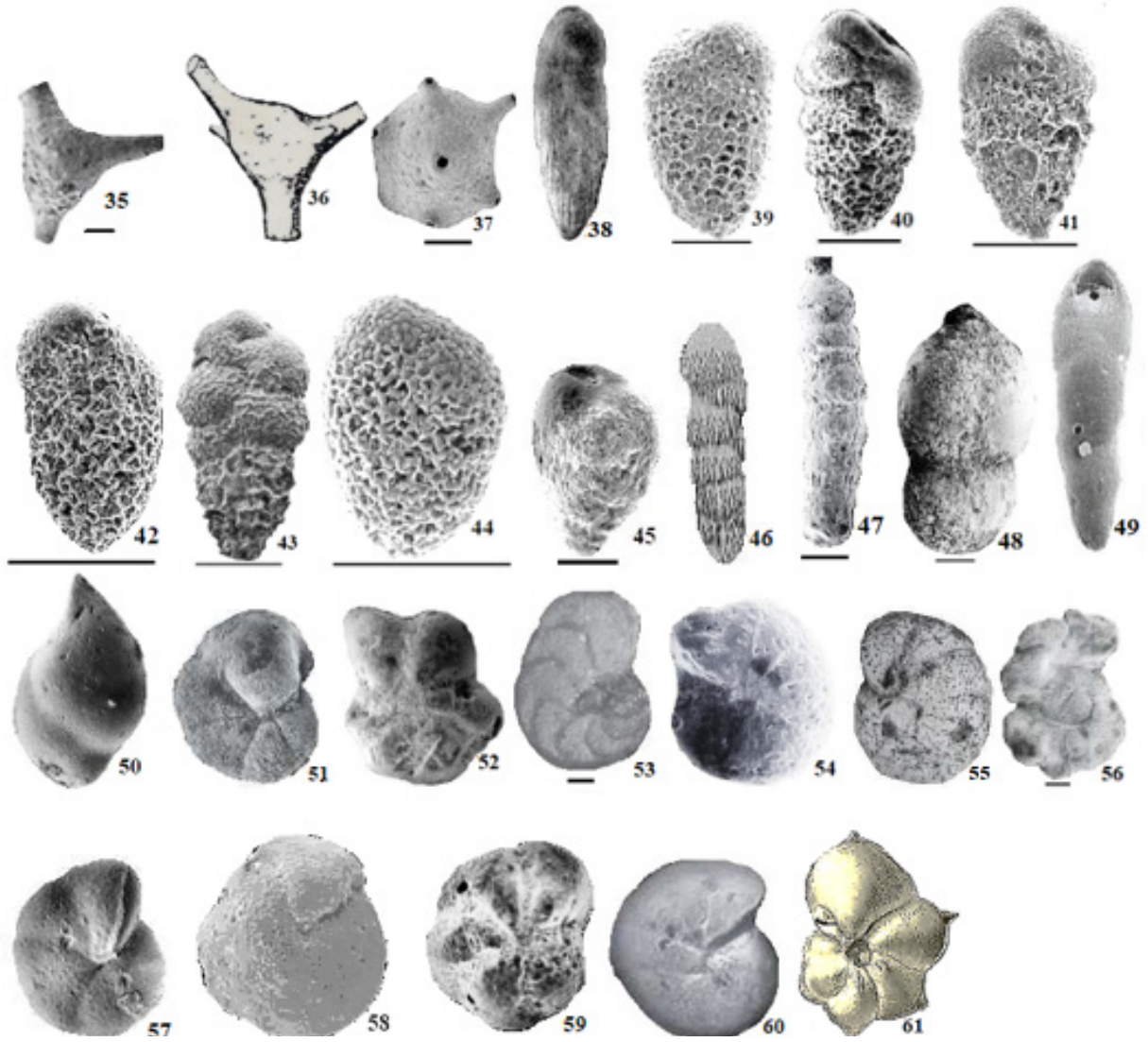

Figure 2 1. *Bathysiphon usamai* Anan,[4] 2. *Orbulinelloides kaminskii* Anan,[6] 3. *Reticulophragmium argentinica* Anan,[7] 4. *Parvigenerina chileana* Anan,[9] 5. *Tritaxia argentinica* Anan,[9] 6. *Gaudryina depressa* Anan,[11] 7. *Gaudryina stasseni* Anan,[13] 8. *Siphogaudryina chileana* Anan,[9] 9. *Siphotextularia argentinica* Anan,[4] 10. *Patellina argentinica* Anan,[9] 11. *Spiroloculina argentinica* Anan,[4] 12. *Quinqueloculina argentinica* Anan,[4] 13. *Laevidentalina jannoui* Anan,[15] 14. *Lagenoglandulina argentinica,*[15] 15. *Lingulina sliteri* Anan,[17] 16. *Tollmannia argentinica* Anan,[19] 17. *Tollmannia fingeri* Anan,[19] 18. *Tristix sliteri* Anan,[17] 19. *Leroyia argentinica* Anan,[19] 20. *Leticuzonaria argentinica* Anan,[19] 21. *Palmula americana* Anan,[19] 22. *Hemirobulina yehiai* Anan,[20] 23. *Marginulina argentinica,*[19] 24. *Vaginulinopsis argentinica* Anan,[15] 25. *Vaginulinoides fingeri* Anan,[1] 26. *Vaginulinoides raoofi* Anan, n. sp., 27. *Vaginulinella fingeri* Anan,[1] 28. *Vaginulina chilensis* Anan,[15] 29. *Lagena chileana* Anan,[21] 30. *Lagena mainayefae* Anan,[21] 31. *Lagena samarae* Anan,[21] 32. *Reussoolina rustomi* Anan,[21] 33. *Ramulina fatemae* Anan,[20] 34. *Ramulina ismaili* Anan,[22] 35. *Ramulina morsii* Anan,[15] 36. *Ramulina plummerae* Anan,[22] 37. *Ramulina subornata* Anan,[19] 38. *Brizalina argentinica* Anan,[21] 39. *Bolivinoidesella ameeri* Anan,[25] 40. *Bolivinoidesella hudae* Anan,[25] 41. *Bolivinoidesella karimae* Anan,[25] 42. *Bolivinoidesella olae* Anan,[25] 43. *Bolivinoidesella pacifica* Anan,[2] 44. *Bolivinoidesella salimi* Anan,[25] 45. *Buliminelloides argentinica* Anan,[30] 46. *Orthokarstenia striata* Anan,[31] 47. *Rectuvigerina argentinica* Anan,[19] 48. *Ellipsoglandulina argentinica* Anan,[32] 49. *Pleurostomella plummerae* Anan,[33] 50. *Pleurostomella abedi* Anan,[32] 51. *Valvulineria nabilae* Anan,[32] 52. *Woodella jawdati* Anan,[31] 53. *Planulina chileana* Anan,[9] 54. *Cibicidoides chilensis* Anan,[35] 55. *Cibicides chileana* Anan,[9] 56. *Falsocibicides chileana* Anan,[9] 57. *Pullenia argentinica* Anan,[9] 58. *Globorotalites mexicana* Anan,[35] 59. *Gyroidina chileana* Anan,[9] 60. *Buccella argentinica* Anan,[9] 61. *Pararotalia loeblichi* Anan.[36]

Remarks: This species has in a low trochospiral nearly planoconvex test, 6 inflated chambers increasing gradually in size as added around deep umbilicus, the spicules giving the chambers a mammilate appearance, radial deep sutures, peripheral outline lobulate with thick keel, aperture interiomarginal extending obliquely up the apertural face.

Paleogeography

The recorded sixty-one benthic foraminiferal species were originally recorded from five different localities in the North America (USA, Mexico), Central America (Caribbean), and South America (Argentina, Chile), and also Atlantic and Pacific Oceans. Some remarks are presented:

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I. *Vaginulinella fingeri* has a wide geographic distribution, which recorded from Chile, Argentina (S. America), USA (N. America), and Caribbean (C. America). *Vaginulinoides fingeri* are recorded from Chile (S. America) and Cuba (C. America).

II. *Vaginulina chilensis* are recorded from Chile (S. America) and Mexico (N. America).

III. The other recorded species are endemic to their original erection.

Paleoenvironment

Major environmental parameters affecting the abundance and distribution of the benthic foraminiferal species include: water depth (Figure 3), type of substrate, temperature, oxygenation, nutrition, organic matter influx on the seafloor, current patterns TCC (Figure 4).

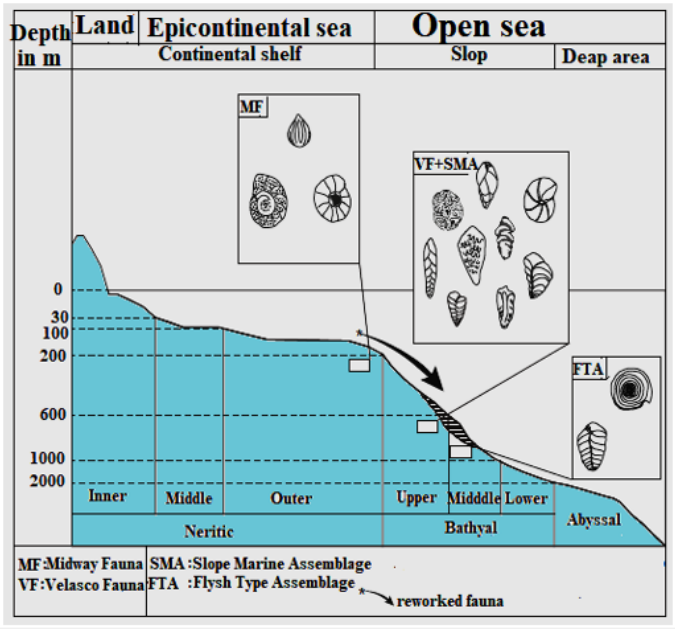

Figure 3 Estimated paleodepths distribution of different foraminiferal environmental groups.[38]

Figure 4 Paleogeography of the Neo-Tethys Ocean during the Maastrichtian showing the flow direction of the Tethyan Circumglobal Current (TCC) from east to west.[39]

Conclusions

The analysis of the Campanian-Neogene benthic foraminiferal species in the America, led to the following conclusions:

I. The taxonomic consideration of the morphological features for sixty-one benthic foraminiferal species from five countries in the North, Central and South America, as well as Atlantic and Pacific Oceans are treated, explained and illustrated.

II. Most of the studied species (~51%) are recorded from Argentina, followed by Chile (~30%), and the others from USA (~9.5%), Mexico (~7.5%) and Caribbean (~2%).

III. Seven species (~13%) belong to Suborder Textulariina, 1 (~2%) to Spirillinina, 2 (~4%) to Miliolina, 25 (~47%) to Lagenina and 18 (~34%) to Rotaliina.

IV. Seven phylogenetic lineages are observed in some benthic foraminiferal species throughout Campanian to Miocene in the study area: (1) *Laevidentalina hudae* → *L. jannoui* → *L. salimi* lineage, (2) *Tollmannia argentinica*→ *T. costata* lineage, (3) *Leroyia aegyptiaca* → *L. argentinica* lineage, (4) *Hemirobulina olae*→ *H. yehiai*→ *H. bassiounii* lineage, (5) *Marginulina argentinica* → *M. costata* lineage, (6) *Ramulina shreifae* →*R. fatemae* lineage, (7) *Orthokarstenia esnehensis*→ *O. eleganta* → *O. striata* lineage.

V. These lineages help, not only to define the major faunal changes throughout the time boundaries, but also to emphasize the stratigraphic importance of them in different localities in the Tethys.

VI. One out of the identified species is treated here to be new: *Vaginulinoides raoofi* Anan, n. sp.

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None.

Conflict of interest

The author certifies that they have no conflict of interest or affiliations with or involvement in any organization or entirely with any financial interest, of non-finical interest in the subject matter or materials discussed in this manuscript.

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