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Four and five-chambered evolution of the late maastrichtian planktic foraminiferal *Plummerita* species in the Tethys

Abstract

Brönnimann[1] proposed two groups from Trinidad, which have spine-like prolongation of ultimate and penultimate chambers of the diagnostic latest Maastrichtian planktonic foraminiferal genus *Plummerita*. As a separate group of this genus, some of it has the last six-chambered volition in *Plummerita reicheli* group (*P. reicheli, P. pustulata, and P. hexacamerata*). The same author also proposed another group related to this genus, with the last five-chambered volution: *P. hantkeninoides* group *(P. hantkeninoides, P. costata and P. inflata*). Nonetheless, another third group was also added to these *Plummerita* assemblages, where Anan[2] added a distinct species of *Plummerita* from the Duwi section, the Red Sea coast of Egypt, *P. haggagae*, which differs from the other species of the *Plummerita* by its four-chambered volution in the last whorl. In the current study, an attempt is made to identify three new species of the planktic foraminiferal assemblages of five-chambers volution, *P. hantkeninoides* group (*P. hodae, P. kellerae, P. premolisilvae*) is believed here to be new, as well as another one four-chamber volution, *P. haggagae* group (*P. elkefensis,* n. sp.), which described from many localities in the Southern Tethys (Tunisia, Egypt, Iraq), and Northern Tethys (Italy). The biostratigraphy, paleogeography, paleoecology, and paleobathymetry of the recorded *Plummerita* members in different Tethyan localities are presented and discussed.

Keywords: *Plummerita*, Foraminifera, Maastrichtian

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Introduction

The test of the genus *Plummerita* is stellate with inflated triangular radially elongated chambers in a low to flat trochospiral and ending in a tubulospine, with surface ornamentation (asteroid or spines with rugosity and costellate in meridional alignment), primary aperture interiomarginal, umbilical covered by tegilla, and meridionally arranged costellae on the surface of the chambers. It is also distinguished by 4-6 chambers in the final whorl (Brönnimann[1], Loeblich and Tappan)[3]. Brönnimann[1] distinguished, from Trinidad, three subspecies of the last five-chambered volution of *Plummerita hantkeninoides* (*hantkeninoides, costata, inflata*) based on the surface ornamentation (asteroid or spines), recorded within the Late Maastrichtian *Globotruncana mayaroensis* Zone. *Plummerita hantkeninoides* has highly characteristic by having radially elongated chambers possessing axially situated spines in the final whorl. These spines may exist in some or all chambers of the last whorl, and the chambers that lack spines are triangular and inflated. Masters[4] considered the latest Maastrichtian three subspecies of *P. hantkeninoides* to represent ontogenetic stages of a single adult species *P. reicheli* and occur after the extinction of *A. mayaroensis*. This opinion is not accepted by Anan[5] and this study, because Brönnimann[1] himself distinguished the last six-chambered volition *(P. reicheli, pustulata, hexacamerata*) as a separate group from another last five-chambered volition *P. hantkeninoides* group *(hantkeninoides, costata, inflata*). Moreover, Anan[6] (pl. 1, figures5, 6) added another distinct species of *Plummerita* from the Duwi section, Red Sea coast of Egypt (Figure 1), *P. haggagae,* which differs from the other species of the *Plummerita* by its four-chambered volution in the last whorl with a strongly rugose surface, low trochoidal volution, wide and deep umbilical area, radiate ridges and axially pointed spine-like prolongation for the three penultimate chambers with axially situated spines, while the end chamber is inflated in a radial chamber without possessing a spine. Another three new species of the five-chambers *P. hantkeninoides* group (*P. hodae, P. kellerae, P. premolisilvae*) and also one new four-chambers *P. haggagae* group (*P. elkefensis*) are believed here to be new.

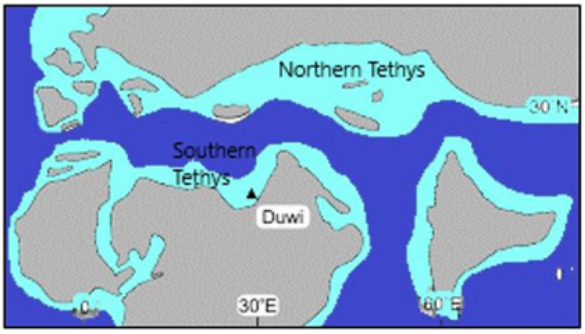

Figure 1 Location map of Duwi section, Red Sea coast, Egypt in the Southern Tethys.[65]

Stratigraphy

Nakkady[7] recorded *Rugoglobigerina reicheli* from the Late Maastrichtian rocks of the Duwi section, Red Sea coast (represents one of the classic localities of the Late Cretaceous/ Paleogene succession in Egypt), as well as Tethys and Atlantic basins. Kerdany & Abdelsalam[8] recorded *P. hantkeninoides* and *R. reicheli hexacamerata* among a rich Maastrichtian foraminiferal assemblage overlying the *Gansserina gansseri* Zone in the Duwi section and erected a new Maastrichtian species *Globotruncana falsocalcarata* with these taxa. In Tunisia, another new species *Globotruncanella kefennsoura* was erected by Solakius[9] from the Late Maastrichtian *A. mayaroensis* and *G. falsocalcarata* Zones, but without *Plummerita* spp. in the assemblage. Masters[10] concluded that *A. mayaroensis* becomes extinct

before the end of the Maastrichtian, and his *P. reicheli* Zone occurs in the Esna Shale of Egypt as it has done in El Haria Shale of Tunisia, above the extinction of *A. mayaroensis*. Thus, where the Maastrichtian is most complete, the *A. mayaroensis* Zone does not represent the latest Cretaceous and the above interval contains *Plummerita reicheli* and occasionally *Globotruncana falsocalcarata.*

The *P. hantkeninoides* Zone represents the latest Maastrichtian biozone in many localities in the Tethys (Figure 2): Trinidad,[11] Mexico,[12] Spain,[13] Italy,[14] Romania,[15] Bulgaria,[16] Tunisia,[17] Egypt,[18] Keller,[19] Samir,[20] Galal,[21] Anan,[6] Obaidalla et al.,[22] Iraq,[23] Iran,[24] Gallala[25] concluded that El Kef section (K/Pg boundary stratotype section and GSSP point) and Ellès section in Tunisia, Agost and Caravaca sections (Betic Cordillera, Spain), relative to the Tethyan realm (low latitude), and Bidart section (France) relative to the Atlantic realm (middle latitude) are complete sections containing all the zones and subzones characterizing the upper Maastrichtian-lower Paleogene interval without any hiatus.

Figure 2 The paleogeographic map of terminal cretaceous showing some studied locations in the open sea Tethys (onlinelibrary wiley.com).

The stratigraphic range (thickness in m.) of the *P. hantkeninoides* Zone in Spain reaches about 3.5 m in the type locality of *P. hantkeninoides* Zone in Spain (Pardo et al.[13]), but 6-9 m in Tunisia,[26] 1-2 m in some localities in Egypt,[27] Keller,[19] Galal,[28]Anan;[5, 6] but 1.4 m in Italy.[12]

Systematic paleontology

The asteroid, rugose, costellate in meridional alignment and axially last four and five-chambered volution spine-like prolongation assemblage *Plummerita hantkeninoides, P. costata, P. inflata* are illustrated (Figure 3. A-I). Another three five-chambered volutions and one four-chambered volution new species are believed to be new: *P. hodae*, *P. kellerae,* and *P. premolisilvae* (Figure 4. A-C) and *P. elkefensis* (Fig. 4. D, E), respectively. These *Plummerita* spp. have been reported, described, and illustrated in some Tethyan localities with some added comments by the present authors. The classification of Loeblich & Tappan[3] is followed here.

Order Foraminiferida Eichwald, 1830

Suborder Globigerinina Delage & Hérouard, 1896

Superfamily Globotruncanacea Brotzen, 1942

Family Rugoglobigerinidae Subbotina, 1959

Genus *Plummerita* Brönnimann, 1952

Type species: *Rugoglobigerina (Plummerella) hantkeninoides* subspecies *hantkeninoides* Brönnimann, 1952

***Plummerita inflata* (Brönnimann, 1952)** - (Figure 3. A-C)

Rugoglobigerina (*Plummerella*) *hantkeninoides inflata* Brönnimann[1], p. 40, pl. 3, figs. 7-9, text-fig. 19a-m.

Plummerita sp. Kassab,[29] p. 350, pl. 2, fig. 5.

Plummerita reicheli (Brönnimann) – Masters,[4] p. 267, pl. 2, figs. 1, 3, 4.

Plummerita hantkeninoides (Brönnimann) – Salaj,[30] p. 302, pl. 16, fig. 12 - Ismail[31], p. 332, pl. 3, fig. 10 – Keller,[19] p. 81, pl. 2, fig. 10 (*non* figs. 7-9) – Obaidalla,[32] p. 214, pl. 1, fig. 8.

Plummerita inflata (Brönnimann). Anan,[5] p. 594, pl. 1, fig. 3.

Remarks: The first three chambers in the last whorl of *P. inflata* are characterized by axially pointed spine-like prolongations, while the last two chambers are strongly inflated shapes without spines.

***Plummerita costata* (Brönnimann, 1952)** - (Figure 3. D-F)

Rugoglobigerina (*Plummerella*) *hantkeninoides costata* Brönnimann,[1] p. 40, pl. 3, figs. 4-6, text-fig. 18a-c.

Plummerita reicheli (Brönnimann) – Masters,[4] p. 267, pl. 1, figs. 7, 8, pl. 2, fig. 2 - Lüning et al,[33] p. 158, fig. 3. 3.

Plummerita hantkeninoides Brönnimann. Keller,[19] p. 81, pl. 2, fig. 9 (*non* figs. 7, 8, 10) - El-Dawy,[34] p. 51, pl. 1, figs. 10, 11 - Darvishzad et al,[24] p. 142, pl. 2, fig. 1 – Gallala,[25] p. 13, fig. 13. 5 (*non.* 1-4) - Orabi & Zahran,[35] p. 80, fig. 1. 10 - Coccioni & Premoli Silva,[14] p. 59, pl. 2, figs. 13, 14 (*non* figs. 12, 15, 16).

Plummerita costata (Brönnimann) – Anan,[5] p. 594, pl. 1, fig. 2.

Remarks: *P. costata* is distinguished by its five-chambered volition in dextral coiling, with axially pointed spine-like prolongation for the four penultimate chambers, but without spine-like prolongation of the last inflated chamber.

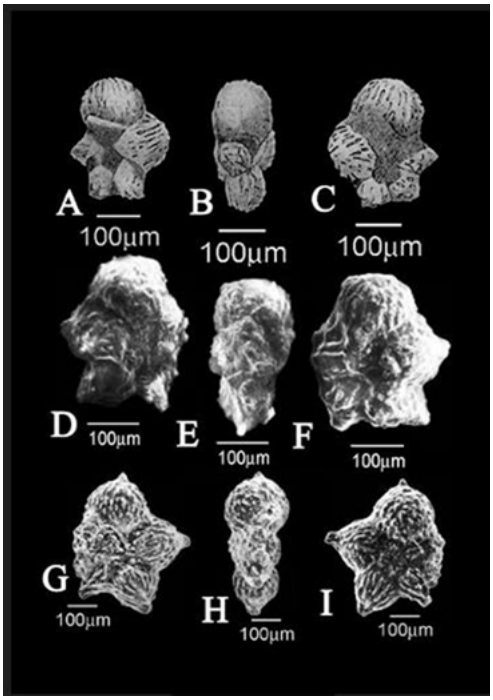

Figure 3 Scale bar = 100 µm

Nos. **A-C,** *Plummerita inflata*, (A. Ventral view, B. Side view, C. Dorsal view), the figured holotype;[1] Nos.

D-F, *Plummerita costata* (D. Ventral view, E. Side view, F. Dorsal view), the figured holotype;[1] Nos.

G-I, *Plummerita hantkeninoides*, G. Ventral view, H. Side view, I. Dorsal view, the figured holotype.[1]

Citation: Anan HS, Orabi OH. Four and five-chambered evolution of the late maastrichtian planktic foraminiferal *Plummerita* species in the Tethys. *J Microbiol Exp.* 2022;10(5):181–187. DOI: 10.15406/jmen.2022.10.00371

***Plummerita hantkeninoides* (Brönnimann, 1952** – ((Figure 3. G-I)

Rugoglobigerina (Plummerella) h. hantkeninoides Brönnimann,[1] p. 37, pl. 3, figs. 1-3, text-fig.1a-k - Bolli et al,[11] p. 43, pl. 43, fig. 5.

Plummerita hantkeninoides (Brönnimann) - Almogi-Labin et al,[36] p. 48, pl. 1, figs. 8, 9.

Plummerita reicheli (Brönnimann) – Masters,[4] p. 267, pl. 1, figs. 1-6, pl. 3, fig. 1- Luger[27], p. 46, pl. 2, figs. 4,9,14 - Robaszynski et al.[37], p. 476. pl. 18, fig. 5.

Plummerita hantkeninoides (Brönnimann). Arz et al,[38] p. 224, pl.1, fig. 7- Karoui-Yaakoub et al,[39] p. 241, pl. 1, fig. 5 – Anan,[40] p. 300, pl. 1, fig. 5 - Coccioni & Premoli Silva,[14] p. 59, pl. 2, fig. 12 (*non* figs. 13-16).

Remarks: *P. hantkeninoides* is characterized by the last five-chambered volition, radially elongated with axially spine-like prolongation of linear pattern rugose surface for all the five chambers in the last whorl.

***Plummerita hodae* Anan, n. sp.** - (Fig. 4. A)

Plummerita inflata (Brönnimann). Anan,[5] p. 594, pl. 1, fig. 3.

Holotype: Fig. 4. A

Dimension: Scale bar=100 µm.

Depository: Geology Department, Ain Shams University-Cairo, Anan collection (ASUGD A38).

Etymology: In the memory of the late mother of the first author Hoda Anan.

Type level and locality: It is recorded with the latest Maastrichtian *Plummerita hantkeninoides* Zone, Duwi section, Red Sea coast, Egypt.

Description: It is distinguished by its radially elongated chambers with axially spine-like prolongation in linear pattern rugose surface in the last whorl with low trochoidal volution. The first three chambers of *P. hodae* have axially protruding pointed spine-like prolongations. The last two chambers are strongly inflated in shape, but without spines for the last fourth and fifth chambers in the last whorl.

Discussion: *Plummerita hodae* n. sp. has the last five chambered volutions as *P. hantkeninoides, P. costata, and P. inflata* Brönnimann.[1] It is closely related to the latter species *P. inflata* (Figure 3.1) but differs from it by the position of its larger fourth chamber than the last fifth chamber, and the third chamber exists perpendicular along the vertical line to the last fifth chamber of the test in the final whorl of the ventral side.

***Plummerita kellerae* Anan & Orabi, n. sp.** - (Figure 4. B)

Plummerita hantkeninoides Keller et al,[19] p. 279, pl. 2, fig. 14.

Holotype: Fig. 4. B.

Dimension: Scale bar=100 µm.

Depositary: The collection of the American paleontologist G. Keller.

Etymology*:* In the honor of the American paleontologist Gerta Keller, Geosciences Department, Princeton University, Princeton, NJ 08544, USA.

Type locality and level: The top 50 cm below the K/T boundary, El Kef section, Tunisia.

Age: Latest Maastrichtian Plummerita hantkeninoides Zone.

Description: It is distinguished by its first three radially elongated chambers with axially spine-like prolongation in linear pattern rugose surface in the last whorl with low trochoidal volution, while the fourth and fifth-last chambers are strongly inflated without spine-like prolongation. The third chamber with axially spine-like prolongation of *P. kellerae* exists perpendicular to the last fifth chamber at the vertical line of the test.

Discussion: *Plummerita kellerae* n. sp. (Figure 4. B) has closely related to the other species *P. inflata* (Figure 3. A-C) and *P. hodae* (Figure 4. A), but differs from it by its first three radially elongate chambers with axially spine-like prolongation, while the last penultimate and ultimate chambers are inflated without spines.

***Plummerita premolisilvae* Anan & Orabi, n. sp.** - (Figure 4.C)

*Plummerita hantkeninoides (*Brönnimann). Coccioni & Premoli Silva,[14] p. 59, pl. 3, fig. 15 (*non* figs. 12-14, 16).

Holotype: Fig. 4. C.

Dimension: Scale bar=100 µm.

Depository: Sample Bottaccione section, BTT 2067 (381.2 m), Gubbio, Italy.

Etymology: In the honor of Italian micropaleontologist Isabella Premoli Silva, Dipartimento di Scienze Della Terra, Ardito Desio, Universita degli Studi di Milano, Italy.

Age: Latest Maastrichtian *Plummerita hantkeninoides* Zone.

Description: It is distinguished by its first two radially elongated chambers with axially spine-like prolongation in linear pattern rugose surface in the last whorl with low trochoidal volution, while the third, fourth, and fifth-last chambers are strongly inflated without spine-like prolongation. The second chamber with axially spine-like prolongation of *P. premolisilvae* exists perpendicular to the last fifth chamber at the vertical line of the test.

Discussion: *Plummerita premolisilvae* n. sp. (Figure 4. C) has also closely related to the other species *P. inflata* (Figure 3. A-C) and *P. kellerae* (Figure 4. B), but differs from it by its only first two radially elongate chambers with axially spine-like prolongation, while the last third, fourth and fifth last chambers are inflated without spines.

***Plummerita elkefensis* Anan and Orabi, n. sp.** - (Figure 4. D, E)

Plummerita hantkeninoides (Brönnimann). Samir,[20] p. 24, pl. 1, fig. 5.

Plummerita hantkeninoides (Brönnimann). Keller,[17] p. 741, pl. 16.4.

Holotype: Fig. 4. D, E

Dimension: Scale bar = 100 µm.

Depositary: The American paleontologist G. Keller collection.

Etymology: After El Kef section, Tunisia.

Age: Latest Maastrichtian Plummerita hantkeninoides Zone.

Description: *P. elkefensis* is characterized by the last four-chambered volition, radially elongated with axially spine-like prolongation of linear pattern rugose surface for all the four chambers in the last whorl.

Discussion: It is distinguished by its radially elongated chambers with axially spine-like prolongation in linear pattern rugose surface in all four chambers in the last whorl with low trochoidal volution.

***Plummerita haggagae* Anan, 2008** - (Figure 4. F, G)

Plummerita hantkeninoides (Brönnimann) - Ziko et al,[18] p. 143, fig. 4. 10, 11 – Keller,[19] p. 81, fig. 8 (*non*-figs. 9, 10) – Galal,[28] p. 246, fig. 7.4 - Obaidalla et al,[22] p. 67, fig. 18.K (*non*-J) - Bamerni et al.,[41] p. 8, pl. 1, figs. 5-8.

Plummerita haggagae Anan,[6] p. 249, pl. 1, figs. 2,3 – Anan,[5] p. 594, pl. 1, figs. 5, 6.

Description: *P. haggagae* is distinguished by its four-chambered volition in dextral coiling, with axially pointed spine-like prolongation for the three penultimate chambers, but without spine-like prolongation of the last fourth inflated chamber. It was recorded, so far, from Egypt and Iraq.

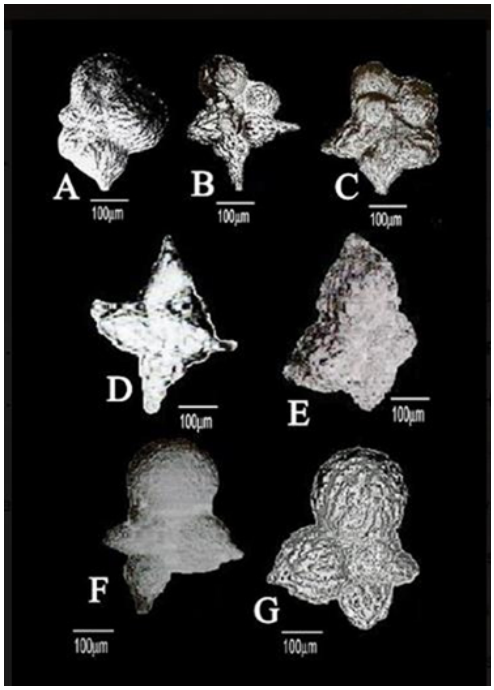

Figure 4 Scale bar = 100 µm

A. *Plummerita hodae* Anan, n. sp., (Dorsal view), the illustrated holotype from Duwi section, Egypt.[5]

B. *Plummerita kellerae* Anan and Orabi, n. sp., (Ventral view), the illustrated holotype from El Kef section, Tunisia.[19]

C. *Plummerita isabellae* Anan and Orabi, n. sp. (Dorsal view), the illustrated holotype from Gubbio section, Italy.[14]

D, E. *Plummerita elkefensis* Anan and Orabi, n. sp., D. (Dorsal view), the figured hypotype,[20] E. (Dorsal view), the figured holotype.[17]

F, G. *Plummerita haggagae* Anan[2], F. (Dorsal view), the figured hypotype,[18] G. (Dorsal view), the figured holotype.[2]

Paleogeography

Keller[42] worked on the high-latitude K/P transition deposits (sites 738C, 752B, 690C) and noted the absence of *P. hantkeninoides*. Consequently, if these species were considered absent in the middle- and high-latitude areas, they would be restricted to low latitudes Keller et al.,[43] used this small-sized species (<150 mm) as the biomarker of the latest Maastrichtian nominate zone. Keller[19] noted that among Rugoglobigerinids, only *P. hantkeninoides, Trinitella scotti,* and possibly *Rugoglobigerina reicheli* are largely restricted to the low latitude Tethys, and these surface dwellers rarely appear in middle latitudes and are generally absent beyond 30° north or south. Gallala[25] noted that *P. hantkeninoides* spp. is absent at middle latitudes: Bidart section (SW France) and Zumaya section (Spain).

One or more representative species of the genus *Plummerita hantkeninoides* group were firstly recorded from Trinidad (Caribbean Sea) by Brönnimann,[1] and after on, it was recorded partly or completely from many other localities in the Tethys, i.e. Colombia,[44] Brazil,[45] Trinidad,[1,11] Mexico,[38] Spain,[13] Italy,[14] Romania,[15] Bulgaria,[16] Tunisia,[46,39] Egypt,[8,10] Jordan,[47] Iraq,[29,23] Iran,[24] Pakistan,[48] Indian Ocean,[49] (Figures 5,6). According to available kinds of literature, it does not record from other Tethyan localities, which may be due to a lack of studies in planktic foraminifera, hiatus around the Cretaceous/Tertiary (K/T) boundary, and/or opportunist climatic conditions. The representative species of the *P. haggagae* were originally recorded from Egypt,[6,17,18,20-22] while *P. elkefensis* were recorded from Egypt,[20] and Tunisia.[17]

Figure 5 The geographic distribution of the identified planktic foraminiferal species of the genus *Plummerita* in some European countries (Spain, France, Italy, Romania, Bulgaria), African countries (Tunisia, Egypt), Asian countries (Jordan, Iraq, Iran, Pakistan).

Figure 6 The geographic distribution of the identified planktic foraminiferal species of the genus *Plummerita* in some American countries, North America (USA, Mexico), South America (Colombia, Brazil).

Paleo environment

Frerichs[50] noted that the radiations of planktonic foraminiferal genera are characteristic of the warm stratigraphic intervals, and the oxygenic level of the atmosphere should be low during times of extinction (e.g. K/T boundary). Dorreen[48] noted that the absence of Late Maastrichtian *Abathomphalus mayaroensis* from the Gaj section in southern Pakistan might well reflect very warm water, while the *G. falsocalcarata* Zone represents the topmost Maastrichtian.

Smith[51] regarded that nearly all species of Late Maastrichtian *A. mayaroensis* Zone are known from deep water of tropical regions, while *G. falsocalcarata*, of probable shallow water species, have not been found with the assemblage, while Anan[52] recognized the top Maastrichtian *A. mayaroensis* Zone in Jiran El Ful section, Abu

Rawash (west Cairo) with a gradual decrease of planktic foraminifera and P/B ratio toward top Maastrichtian, which indicate cold water. Anan & Hewaidy[53] considered the fauna in the Duwi section to be related to the 'Midway-Type Fauna' of Berggren,[54] a middle-outer neritic environment (50-200 m). Keller[55] noted that the absence of *A. mayaroensis* in El Kef, Tunisia represents shallow water conditions, rather than a hiatus.

Anan & Sharabi[56] noted that the upper Maastrichtian dark shales in Kharga Oasis of Egypt containing elongated and rounded red ferruginous mudstone nodules are mainly devoid of index planktonic foraminifera with scarce arenaceous benthonic individuals, which may express shallow environmental conditions, reduced salinities and lowered oxygen levels. Speijer[57] noted that the Late Maastrichtian assemblage of Gabal Duwi has very few taxa in common with the bathyal assemblage. Li & Keller[58] noted that in the Maastrichtian, a short-lived global warming pulse was recorded in the oceans at 65.78–65.57 Ma.

Speijer et al.,[59] noted that the Wadi Nukhul section (Sinai) represents deep basinal deposition (500-600 m), while Gabal Duwi (central Egypt) represents the middle shelf (150-200 m). Alegret et al.,[60] interpreted the bathyal depths during the *A. mayaroensis* through the early *P. hantkeninoides* Biochrons at the Agost section in southeastern Spain. Anan[6] considered Sinai and central Egypt to have a middle-outer neritic environment (50-200 m). Keller[19] noted that *P. hantkeninoides* (in Gabal Qreiya in central Egypt, west of Gabal Duwi) evolved near the lower part of the latest Maastrichtian warm event (~65.3 Ma) and disappeared at the K/T boundary. Keller[17] also added that the global sea level low stand at 65.5 Ma is associated with widespread erosion. Al-Wosabi & Abu Shama[61] noted that *P. hantkeninoides* is attractive to warm-water conditions, and El-Sabbagh[62] also noted that the peak abundance in *P. hantkeninoides* Zone in western Sinai may reflect the global warming event between 65.4-65.2 Ma.

Gertsch et al.,[63] noted that during the latest Maastrichtian, periodic acid rains (carbonate dissolution; CIA index: 70–80) associated with pulsed Deccan eruptions in India and strong continental weathering resulted in mesotrophic waters, and resulting super-stressed environmental conditions led to the demise of nearly all planktic foraminiferal species and blooms of the disaster opportunist *Guembelitria cretacea*. Keller[64] noted that the discovery of the direct link between Deccan volcanism (west India) and the end-Cretaceous mass extinction also links volcanism to the late Maastrichtian rapid global warming and high environmental stress (Figure 7).

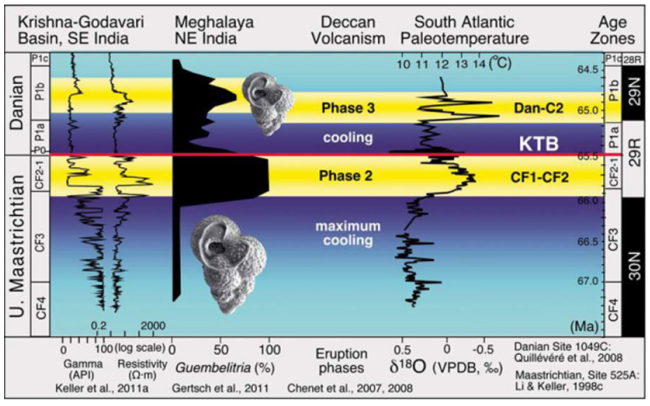

Figure 7 Deccan phase 2 and phase 3 volcanism is correlative with global warming events in the late Maastrichtian zones CF1-CF2 and the early Danian. Dan-C2 event in zone P1b. KTB-Cretaceous-Tertiary boundary; API-American Petroleum Institute units; VPDB-Vienna Peedee belemnite.[67]

Conclusion

The rich and well-preserved Late Maastrichtian planktic foraminifera *Plummerita* spp. of the most studied section in the Tethys made it possible to improve the biostratigraphic resolution and to clarify some aspects of the paleoecology, paleoenvironments, and paleogeography. Combining this with data available from previous studies, the following conclusions are presented:

- The studied latest Maastrichtian horizon is attributed to the *P. hantkeninoides* Zone. It coincides with *P. reicheli* Zone by some authors or the *K. falsocalcarata* Zone by others. The underlying *A. mayaroensis* Zone and its nominated species were mainly recovered in Egypt.
- The *Plummerita* spp. (Frerichs[50]) are mostly representing a warm water environment.
- The three latest Maastrichtian planktic foraminiferal *P. hantkeninoides* group (five-chambered volition): *P. hantkeninoides, P. costata, P. inflata*, and the proposed three new species: *P. hodae, P. kellerae,* and *P. premolisilvae* are recorded and illustrated. The two species of the *Plummerita haggagae* group (four-chambered volition): *P. haggagae* and *P. elkefensis*) are illustrated in this study, the second one for the first time.
- The wide geographic distribution of the *P. hantkeninoides* (s. l.) in different localities in central Egypt (Gabal Duwi and G. Qreiya), and Sinai (Themed area and Abu Zenima area at East and West Central Sinai, respectively) are controlled by most probably similar, deep marine, outer shelf-upper bathyal environment, 200-400 m.[19]
- The high diversity and abundance of the planktic and benthic foraminifera in the top Maastrichtian chocolate marl beds in the Duwi section seem to be deposited in rich nutrient upwelling water.[2]
- The dark shale that rests on the top Maastrichtian horizon in some Tethyan territories i. e. Gabal Duwi, Red Sea coast in Egypt (Anan[2,6]), G. Qreiya in Kharga Oasis, Egypt. (Keller[19]); El Kef section, Tunisia (Keller[46]), Upper Magdalena Valley succession in Colombia (Vergaras[44]) is most probably indicative of low oxygenic level, stagnation of the sea leading to enhanced preservation and high concentration of organic matter.
- Keller[64] noted that the discovery of the direct link between Deccan volcanism (west India) and the end-Cretaceous mass extinction also links volcanism to the late Maastrichtian rapid global warming and high environmental stress.

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Conflicts of interest

The authors declare that there is no conflict of interest.

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