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Hantkeninidae (Planktonic Foraminifera) from the Middle-Upper Eocene of Jabal Hafit, United Arab Emirates

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ABSTRACT

Six species of the planktonic foraminiferal Family Hantkeninidae belonging to the genera namely *Cribrohantkenina* and *Hantkenina* are recorded and described from the Middle**-** and Upper Eocene succession of Jabal Hafit, Al Ain area, United Arab Emirates. The species include *Cribrohantkenina inflata, Hantkenina alabamensis, H. compressa, H. australis, H. liebusi and H. primitiva*. The three species of *Hantkenina* named last are recorded for the first time from the UAE**.**

Keywords: Middle Eocene, Upper Eocene, Hantkeninidae species, United Arab Emirates

INTRODUCTION

The species of the genera *Cribrohantkenina* and *Hantkenina* have a worldwide distribution encircling low and mid-latitudes. The appearance of the genus *Hantkenina* at 49 Ma corresponds with the Early/Middle Eocene boundary, and their extinction at 33.7 Ma denotes the Eocene/Oligocene boundary, while the genus *Cribrohantkenina* appears only at the Late Eocene (36. 4 Ma-34. 3 Ma) and its extinction denotes the Eocene/Oligocene boundary. Pearson (1993) noted that the genus *Hantkenina* have a rounded periphery and more globose chambers (*e.g. H. alabamensis*) and sometimes areal apertures on the chamber face around the primer aperture (=*Cribrohantkenina*). Coxall *et al.* (2003); Coxall and Pearson (2006)**;** and Rögl and Egger (2010) noted that the genus *Hantkenina* evolved gradually from the genus *Clavigerinella* in the earliest Middle Eocene, contrary to the long-held view that it is related to the genus *Pseudohastigerina* evolved from *Globanomalina luxorensis* (Nakkady) in the earliest Early Eocene (base of Zone E2) by the development of a symmetrical umbilical aperture and slightly asymmetrical to fully planispiral test as are the result of changes in the timing of the development processes. Rögl and Egger (2010) noted that the first appearance of *Hantkenina* can mark the base of the Middle Eocene, and in the study area the Ypresian-Lutetian boundary is an unconformity that encompasses a major stratigraphic gap, which is named by Anan (2015b) as '*pentacamerata* Event'. It ranges from Middle to Upper Eocene. The nominate species represent the *Hantkenina alabamensis* Zone (E16) and mark the end of the Late Eocene (Berggren and Pearson, 2005, 2006).

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The present paper is one of the series of studies of foraminiferal assemblages from the Eocene succession of Al Ain area, UAE (Fig. 1). The current work presents a study of the Hantkeninidae planktic foraminiferal assemblages of the top Middle-Upper Eocene succession from the eastern limb in Jabal Hafit, UAE (Fig. 2). The previous studies of Cherif *et al.* (1992), Anan *et al.* (1992), Anan (1994, 1995, 1996, 2015a), Abdelghany (2002), Boukhary *et al.* (2006) are applicable to the present study.

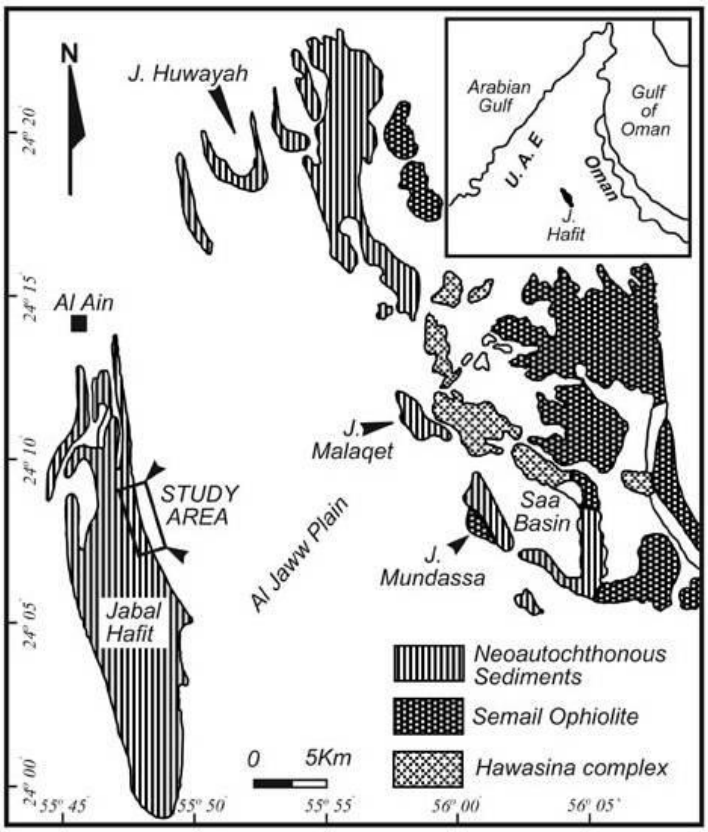

Fig. 1: Location map of the study section, eastern limb of Jabal Hafit, Al Ain area, UAE.

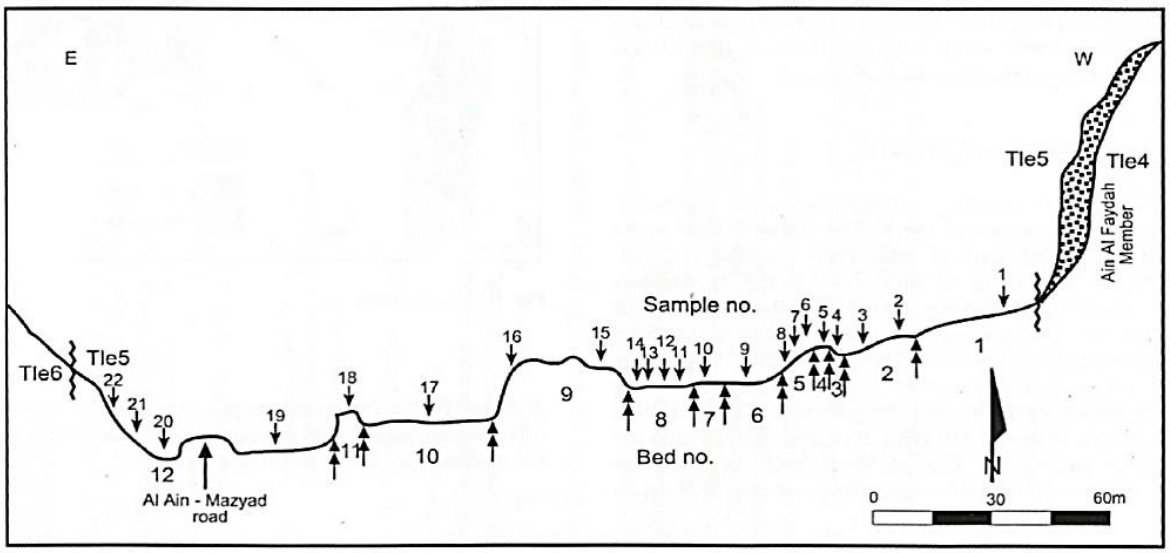

Fig. 2: Schematic diagram of the study section (Tle5, between Tle4 and Tle6), the lower part of the Mazyad Member, Dammam Formation, eastern limb of J. Hafit (after Anan, 2005).

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MATERIAL OF STUDY

Twenty two samples were collected from the nearly 249 m thick vertical succession of the Middle-Late Eocene sediments of the eastern limb of Jabal Hafit anticline (Lat. 24° 06'-24° 9' N, Long. 55° 46'- 55° 49'E, Fig. 1), which is exposed in Al Ain-Mazyad road (Fig. 2). This exposure (twelve beds of alternating shale, marl and marly limestone) is equivalent in part to the Tle5 of Hunting, 1979 (where T=Tertiary, l=Lower, e=Eocene, 5=the number of the coded mappable rock unit of Jabal Hafit and other outcrops in the Al Ain area), and of the lower part of Mazyad Member of the Dammam Formation of Hamdan and Bahr, 1992.

STRATIGRAPHY

The tropical and subtropical planktic foraminiferal zones of Berggren and Pearson (2005) and Pearson *et al.,* 2006 (*in* Atlas of Eocene planktonic foraminifera) are used for the section under investigation (Tle5 succession) in J. Hafit, which is represented by four planktic foraminiferal biozones, from base to top: the upper part of the Middle Eocene (late Bartonian) *Morozovelloides crassata* Zone E13, *Globigerinatheka semiinvoluta* Zone E14 (Middle-Upper Eocene, late Bartonian- early Priabonian),*G. index* Zone E15 (late Eocene, Priabonian) and *Hantkenina alabamensis* Zone E16 (late Priabonian). The Glauconitic limestone bed (no. 8, about 15 m thick) separates the biozones E13 and E14. On the other hand, Anan (2014) noted that the stratigraphic analysis of the Middle-Upper Eocene succession of J. Hafit indicated two unconformities marked by two distinct intraformational conglomerate beds. The first one was deposited within the top part of the Middle Eocene (between Tle4 and Tle5 with about 25 m thick), and also at the lower/middle Upper Eocene contact representing the younger intraformational conglomerate bed no. 11 (about 2 m thick, Fig.3). The phosphatic limestone bed no. 9 (about 25 m thick) represents the passage between the Middle and Upper Eocene succession in the study section (see Fig. 2).

The upper Middle-upper Eocene planktic foraminiferal taxonomy by Pearson *et al.* (2006) and biozones of Berggren and Pearson (2005) at Jabal Hafitare followed. Six Hantkeninidae planktic foraminiferal species from the Bartonian to Priabonian zones of Jabal Hafit are recorded and illustrated (Figs. 4, 5). These include: *Cribrohantkenina inflata* (Howe), *Hantkenina alabamensis* Cushman, *H. australis* Finlay, *H. compressa* Parr, *H. liebusi* Shokhina and *H. primitiva* Cushman and Jarvis.

Order: Foraminiferida Eichwald, 1830
Suborder: Globigerinina Delage and Hérouard, 1896
Superfamily: Globigerinacea Carpenter, Parker and Jones, 1862
Family: Hantkeninidae Cushman, 1927
Genus: *Cribrohantkenina* Thalmann, 1942
Type species: *Hantkenina inflata* Howe, 1928
Cribrohantkenina inflata (Howe, 1928)
Fig. 5a

1928. *Hantkenina inflata* Howe, p. 14, pl. 14, fig. 2.
1969. *Cribrohantkenina inflata* (Howe)- Samanta, p.337, pl. 1: figs. 11a-b
1975.*Cribrohantkenina inflata* (Howe)- Martinez-Gallego and Molina, p. 178, pl. 1, fig. 2.
1979. *Cribrohantkenina inflata* (Howe)- Blow, p. 1171, pl. 52, figs. 1-3.
1992.*Cribrohantkenina inflata* (Howe)- Anan *et al.,* p. 236, pl. 8, fig. 8.

1995. *Cribrohantkenina inflata* (Howe)- Anan, p. 8, pl. 1, figs. 14, 15.
2002. *Cribrohantkenina inflata* (Howe)- Abdelghany, p. 215, pl. 2, figs. 3-6.
2006. *Cribrohantkenina inflata* (Howe)- Coxall and Pearson, p. 226, pl. 8.3, figs. 1-16.
2015.*Cribrohantkenina inflata (*Howe)- Pearson and Wade, p. 20, figs. 22.1a-3b, 23.1a-21.

Remarks: The genus *Cribrohantkenina* is regarded as a monotypic genus. The critical feature for inclusion is the presence of at least one areal aperture, specimens similar in all other respects but lacking areal apertures are assigned to *Hantkenina*. Some authors (*i.e.* Blow, 1969; Toumarkine and Luterbacher, 1985; Anan, 1995; Coxall and Pearson, 2006; Pearson and Wade, 2015) consider the genus *Cribrohantkenina* to have evolved from the genus *Hantkenina*. *Cribrohantkenina inflata* always bordered by a smooth lip symmetrically disposed across the equatorial plane. It is recorded in low-mid latitudes, but absent from the high northern and southern latitudes (Coxall and Pearson, 2006). It is originally recorded from Alabama, USA, and later from many sites over the world including Spain, Italy, southwest coast of Africa, east Africa (Tanzania), UAE, Gulf Coast of USA and India.

Genus: *Hantkenina* Cushman, 1924
Type species: *Hantkenina alabamensis* Cushman, 1924
*Hantkenina alabamensis*Cushman 1924
Fig. 5b

1924.*Hantkenina alabamensis* Cushman, p. 3, pl. 1, figs. 1-6, pl. 2, fig. 5, text-fig. 1.
1968. *Hantkenina alabamensis* Cushman-Srinivasan, p. 145, pl. 13, figs. 5, 6, 9.
1969. *Hantkenina alabamensis* Cushman-Samanta, p. 338, pl. 3, fig. 3 a, b.
1973. *Hantkenina alabamensis* Cushman-Krasheninnikov and Hoskins, p. 123, pl. 31, figs. 3, 6.
1975.*Hantkenina alabamensis* Cushman-Toumarkine and Bolli, p. 81, pl. 1, figs. 10-13.
1983.*Hantkenina alabamensis* Cushman- Miller, p. 439, pl. 5, fig. 10.
1984. *Hantkenina alabamensis* Cushman-Lazarus and Prothero, p. 168, fig. 2. Ha.
1985.*Hantkenina alabamensis* Cushman- Toumarkine and Luterbacher, p. 123, fig. 25. 1-10.
1990.*Hantkenina alabamensis* Cushman-Premoli Silva and Spezzaferri, p. 303, pl. 1, figs. 4.6
1992. *Hantkenina alabamensis* Cushman- Milner, p. 83, pl. 6, fig. 8.
1992.*Hantkenina alabamensis* Cushman- Anan *et al.,* p.236, fig. 8. 6.
1995. *Hantkenina alabamensis* Cushman-Anan, p. 7, pl. 1, fig. 16.
1997. *Hantkenina alabamensis* Cushman- Mukhopadhyay, p.220, pl. 2, fig.21.
1999. *Hantkenina alabamensis* Cushman-Imam, p. 631, fig. 7. 15.
2002. *Hantkenina alabamensis* Cushman-Abdelghany, p. 215, pl. 2, figs. 7, 8.
2003. *Hantkenina alabamensis* Cushman- Mukhopadhyay, p.22, pl. 1, figures 5 - 6.
2006.*Hantkenina alabamensis* Cushman-Molina *et al*., p. 274, pl. 1, fig. 7.
2006. *Hantkenina alabamensis* Cushman-Coxall and Person, p. 230, pl. 8.4, figs. 1-16.
2008.*Hantkenina alabamensis* Cushman-Abd El-Aziz, p. 29, pl. 2, fig. 12.
2015.*Hantkenina alabamensis* Cushman-Pearson and Wade, p. 22, fig. 24.1a-6b.

Remarks: Coxall *et al.* (2003) noted that the genus *Hantkenina* evolved gradually from the genus *Clavigerinella* in the earliest Middle Eocene and contrary to the long-held view it is related to the genus *Pseudohastigerina.* The cosmopolitan species *H. alabamensis* is the most advanced representative of the genus that ranges from the Middle to Upper Eocene. The nominate species represents the *Hantkenina alabamensis* Zone (E16) extending up to Late Eocene (Pearson and Wade 2005 and Berggren and Pearson 2006). It is recorded from many parts of the Tethys: Mexico, Spain, Italy, Egypt, UAE, India and New Zealand.

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Fig. 3: A 'head-like' rock consists a part of an intraformational conglomeratic limestone bed (bed no. 11) at the E14/E15 (=P15/P16) boundary in the study section (after Anan, 2014).

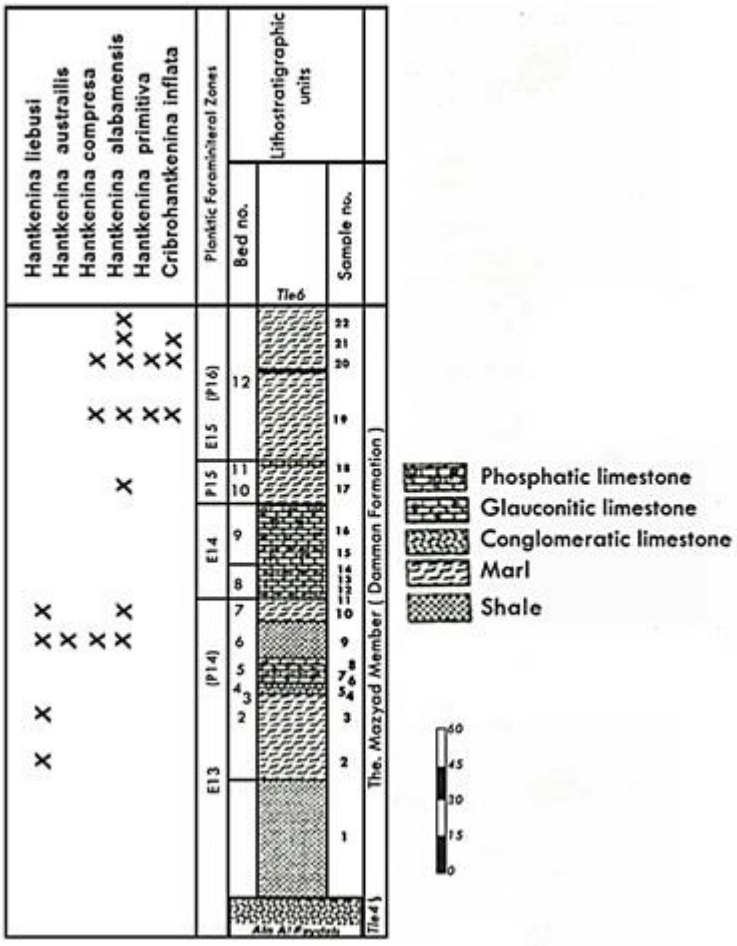

Fig. 4: Stratigraphic ranges of the species of Hantkeninids from the Middle-Upper Eocene succession.

Hantkenina australis Finlay, 1939
Fig. 5c

1939. *Hantkenina australis* Finlay- p. 538, pl. 56, figs. 20, 21.
2006. *Hantkenina australis* Finlay- Coxall and Pearson, p. 232, pl. 8.5, figs. 1-15.

Remarks: This species is distinguished by its appressed triangular chambers in the final whorl, and slender tubulospine curved backward slightly in the opposite direction to coiling. According to Coxall and Pearson (2006), it shows features of *H. dumblei* and *H. compressa* but differs from both and all other species of *Hantkenina* in having posteriorly recovered tubulospine, and probably evolved from *H. dumblei* in the middle Eocene. It is recorded so far from few parts of the Tethys: New Zealand, Labrador Sea, and now in the UAE for the first time.

Hantkeninacompressa Parr, 1947
Fig. 5d

1947. *Hantkenina compressa* Parr- p. 46, text-figs. 1-7.
2003. *Hantkenina compressa* Parr- Coxall *et al.,* p. 243, pl. 2, fig. 13, pl. 4, figs. 10, 12, 13, 14.
2006. *Hantkenina compressa* Parr- Coxall and Person, p. 233, pl. 8.6, figs. 1-21.
2015. *Hantkenina compressa* Parr- Pearson & Wade, p. 22, pl. fig. 24.7-12b.

Remarks: Coxall and Person (2006) noted that this species is distinguished from *H. alabamensis* in lacking the subtangential adult tubulospine in having more laterally compressed chambers, and intermediate in morphology between *H. dumblei* and *H. alabamensis* and overlaps stratigraphically with them both. Person & Wade (2015) noted that the morphospecies *H. alabamensis* and *H. compressa* seem to be linked by a continuous gradation of morphology. This species is also very similar to *H. primitiva* in its compressed morphology and tubulospine position, but has tubulospine on every chamber of the final whorl. It is also recorded from Australia, Tanzania, and now in the UAE for the first time.

Hantkenina liebusi Shokhina, 1937
Fig. 5e

1937. *Hantkenina liebusi* Shokhina- p. 427, pl. 2, fig. 4.
1970. *Hantkenina liebusi* Shokhina- Mohan and Soodan, p. 42, pl. 2, figs. 6, 8.
1978. *Hantkenina liebusi* Shokhina- Gasiński, p. 43, fig. 9 (1-20), fig. 10 (21-35), fig. 11 (36-38) pl. 1, fig. 1-7, pl. 2, fig. 1-5.
1989. *Hantkenina liebusi* Shokhina- Haggag, p. 127, fig. 8. 2.
2003.*Hantkeninaliebusi* Shokhina- Coxall *et al.,* p. 246, pl. 4, figs. 1, 2, 7, 8.
2006. *Hantkenina liebusi* Shokhina- Coxall and Person, p. 238, pl. 8.7, figs. 1-20.

Remarks: The last whorl of this species has generally 5-6 subtriangular chambers with a great degree of growth, increase rapidly in size as added. Each chamber extends into a hollow tubulospine and the chambers are very closely connected with each other; thus the outline of the test is less stellate. Jenkins (1965) noted that some of the specimens of *H. liebusi* illustrated by Shokhina (1937, fig. 8) show slightly recurved spines, and this may account for the similarity in morphology, and when the topotype material of *H. liebusi* becomes available, the two species may prove to be conspecific. *H. liebusi* evolved from *H. mexicana* in the early Middle Eocene in a higher stratigraphic level, and give *H. australis*

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through *H. dumblei* (Coxall and Person, 2006). It is recorded in the mid to low latitudes (*i.e.* Russia, India, Poland, Egypt and Tanzania), and now in the UAE for the first time.

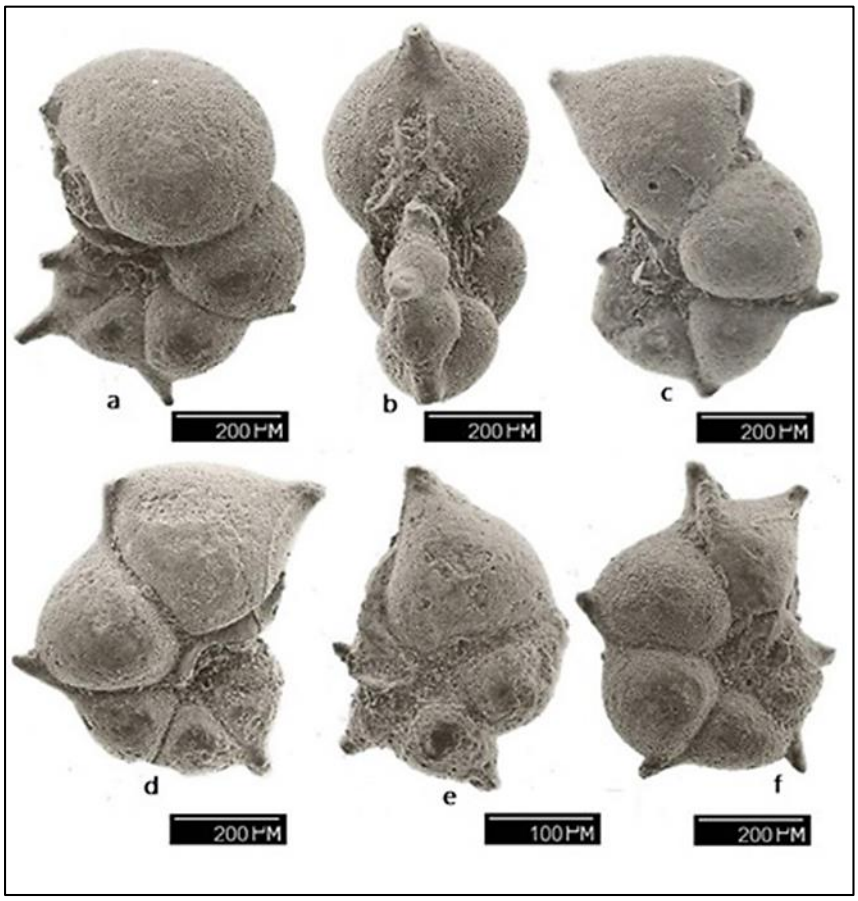

Fig. 5: a: *Cribrohantkenina inflata* (Howe, 1928), Sample 20, Upper Eocene (side view presents the cribrate supplementary aperture). b: *Hantkenina alabamensis* Cushman 1924**,** S. 20, Upper Eocene (apertural view with two diagnostic apertural flanges). c: *H. australis* Finlay, 1939, S. 6, Middle Eocene (side view with incompletely backward curved preserved spines). d: *H. compressa* Parr, 1947, S. 19, Upper Eocene (side view with wide flaring lip bordered the aperture). e: *H. liebusi* Shokhina, 1937, S. 3, Middle Eocene (side view, about 4½ shorter adult chambers with incised peripheral outline). f: *H. primitiva* Cushman and Jarvis, 1929**,** S. 20, Upper Eocene (side view with 5 chambers increasing steadily in size as added and tubulospines arising sharply from the supporting chamber).

Hantkenina primitiva Cushman and Jarvis, 1929
Fig. 5f

1929. *Hantkenina alabamensis* Cushman var. *primitiva* Cushman and Jarvis, p.16, pl. 3, figs.2, 3.
1969. *Hantkenina primitiva* Cushman and Jarvis- Samanta, p. 340, pl. pl. 1, fig. 9.
1992. *Hantkenina primitiva* Cushman and Jarvis- Anan *et al.,* p. 236, pl. 8, fig. 7.

1985. *Hantkenina primitiva* Cushman and Jarvis- Toumarkine and Luterbacher, p.124, figs 25.13-15.
2006. *Hantkeninaprimitiva* Cushman and Jarvis- Coxall and Person, p. 250, pl. 8.12, figs. 1-20.
2015. *Hantkenina primitiva* Cushman and Jarvis- Person and Wade, p. 23, fig. 25.5a-9b.

This species in the last whorl has generally 5-6 appressed polygonal chambers extended into hollow tubulospine and increasing steadily in size as added. Toumarkine and Luterbacher (1985) noted that *Hantkenina primitiva* differs from *H. alabamensis* mainly by the ontogenetically late development of the spines which are present only in the last 2 or 3 chambers. In addition, *H. primitiva* is distinguishable from *H. alabamensis* by its more embracing and laterally more compressed chambers. *Hantkenina primitiva* is distinguished from *H. australis* by having straight rather than the recurved tubulospine. The species might have evolved from *H. compressa* at the base of Zone E13 (Coxall and Pearson, 2006). It is recorded from some locales in the Tethyan province includingTrinidad, Tanzania, UAE and India.

SUMMARY AND COCLUSIONS

1. All the six identified Hantkeninids species (*Cribrohantkenina inflata, Hantkenina alabamensis, H. australis, H. compressa, H. liebusi* and *H. primitiva*) are recorded from the Middle-Upper Eocene succession of the eastern limb of Jabal Hafit, Al Ain area, UAE.
2. Of the identified six species, three (*H. australis, H. compressa* and *H. primitiva*) are recorded from the study section for the first time.
3. Four species recorded from the Middle Eocene include *Hantkenina alabamensis, H. australis, H. compressa*and *H. liebusi* while two species namely *Hantkenina alabamensis* and *H. compressa* continue into the Upper Eocene.
4. The two species *C. inflata* and *H. primitiva* are recorded only in the Upper Eocene.
5. The presence of accessory apertures and tubulospines in the Hantkeninids planktonic foraminiferal species are suggested by many authors (*i.e.* Coccioni, 1988; Anan, 1994; Coxall and Pearson, 2006) to be restricted in the mid to low latitudes, in open ocean and shelf paleoenvironments and tropical-subtropical warm-temperate regions.
6. The world distribution of the identified Hantkeninids species supports the interpretations presented by some authors (Berggren, 1978; Moore *et al*., 1978; Adams *et al*., 1983; Keller, 1983; Anan, 1995, 2009; Pearson *et al.*, 2004; Wade and Pearson, 2008) about the extended realms of Tethys, Indo-Pacific with Atlantic during the Middle-Late Eocene time.

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