# Larger foraminiferal biostratigraphy of the upper Cretaceous (Campanian) to Paleogene (Lutetian) sedimentary rocks in the Haymana and Black Sea regions, Turkey

**Kuniteru Matsumaru**
*Innovation Research Organization, Saitama University, Saitama 338 8570, Japan*
email: matsumar@mail.saitama-u.ac.jp

**ABSTRACT:** Larger foraminifera of the late Cretaceous (late Campanian) to middle Eocene (Lutetian) are recognized in the upper Cretaceous to Paleogene sedimentary rocks in the Haymana and Black Sea regions, Turkey. 114 diagnostic larger and benthonic foraminiferal species belonging to 66 genera including one new genus *Chaldagia* are identified, and 89 diagnostic species are documented as local ranges. Biostratigraphically useful 11 larger foraminiferal assemblage zones are described, and are correlated with two larger foraminiferal assemblage zones, NE India and Philippines in the Tethys region. *Chaldagia haymanensis*, n. gen., n. sp. and *Scandonea samnitica* De Castro are systematically described. Associated 52 planktonic foraminiferal species belonging to 23 genera are identified, and 90 larger and benthonic foraminifera and 40 planktonic foraminifera are illustrated. Some element concentrations of the Cretaceous-Tertiary (K-T) boundary layers (28-37 cm thick with goethite layers) were found in the Medetli section, Görpazari, Black Sea region by the author's research group. In there, Ir concentration was low and slightly elevated (0.24 ppb) in a sample of goethite layers, and foraminiferal taxa didn't yield. The K-T Ir layers are well correlated with those in the Meghalaya, NE India. Sr isotope values (87 Sr/86 Sr, 0.707885 – 0.707819) in the K-T boundary layers in the Devrekani section, Kastamonu, Black Sea region agreed well with those in the K-T boundary regions of the world by the author's research group.

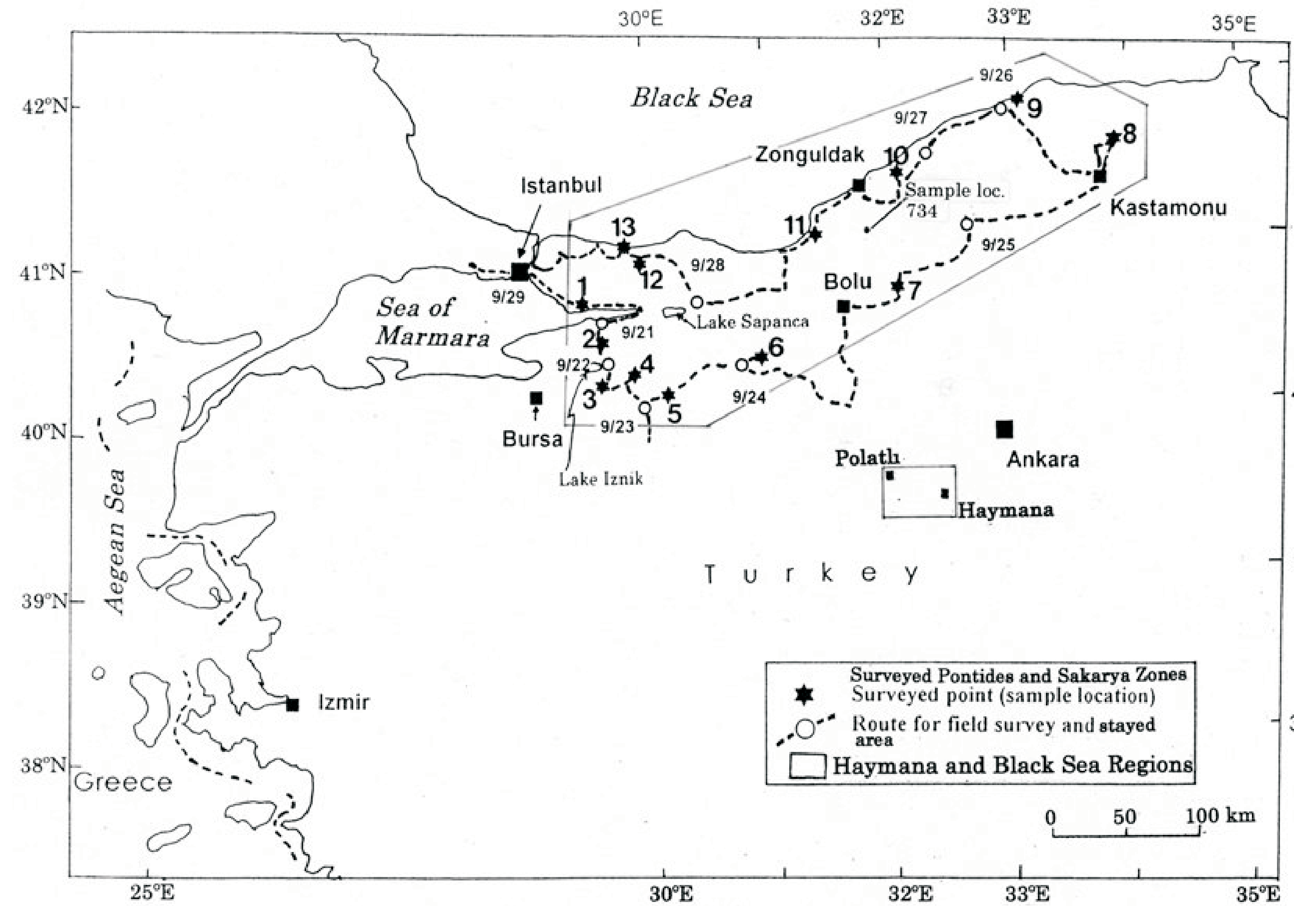
## INTRODUCTION

The upper Cretaceous to Paleogene limestone, marl, alternation of limestone, marl and shale, and calcareous sandstone are widely exposed in the Sakarya zone of the Haymana region and the Pontides - Sakarya zones of the Black Sea region, main tectonic units of Turkey, respectively (Matsumaru et al. 2010, text-fig. 1) (Text-figures 1-2). The author has researched the late Cretaceous to Paleogene (early Paleocene to middle Eocene) foraminifera in the General Directorate Mineral Research and Exploration (M.T.A.:Maden Tetkik ve Arama Enstitüsü), Ankara, Turkey in 1992 by the Grant-in-Aid for Scientific Research of the Japan Society for the Promotion of Science (JSPS); as the Regional Subcommittee of West Pacific of IGCP Project N. 286, third Meeting, Ankara (Turkey), Oct. 08-13, 1992; and in its pre-research field survey of IGCP Project N. 286 Field-Trip (M.T.A. 1992). The present study has continued several times in the field and laboratory works with Turkey scientists, i.e. Oversea Field Research, Project No. 7041086 in 1995 and No. 11640486 in 1999 by the Ministry of Education, Science and Culture, Japan; Oversea research in 1998 by the Grant-In-Aid of Saitama University, and private research (Matsumaru et al. 1996, 1997, 1998; Matsumaru 1997; Matsumaru in Arakawa et al. 2003). Samples of this study were collected in all the research stated above, and also partial private comparative samples by Drs. Engin Meriç, Izver Tansel Öngen, Kemal Erdoğan, Sükrü Aca, and Erciment Sirel were considered in this study.

The purpose of this study is to describe the larger foraminifral biostratigraphy and assemblages from the long term research of diagnostic larger and benthonic foraminifera, associated with planktonic foraminifera from the upper Cretaceous to Paleogene sedimentary rocks in the Haymana and Black Sea regions, Turkey. 114 diagnostic species of 66 genera, included *Chaldagia haymanensis,* n. gen., n. sp. (Text-figures 5A, 5B, 10A, 10B) and associated planktonic foraminifera of 52 species of 23 genera were found in this study (Text-figures 6A, 6B, 11A, 11B). *Chaldagia haymanensis*, n. gen., n. sp. and *Scandonea samnitica* De Castro are described, but not described other diagnostic foraminifera due to space limitation. The age diagnostic 90 larger and benthonic foraminifera and 40 planktonic foraminifera are, however, illustrated in Plates 1-16 and Plates 17-22, respectively. This study provides 11 larger foraminiferal assemblage zones for the international correlation, and these zones are recognized (Text-figures 12-13). Biostratigraphic synthesized ranges of 89 diagnostic larger and benthonic foraminifera are shown (Text-figure 13). Further, element profiles and Ir concentration of the Cretaceous – Tertiary (K-T) boundary layers (Taraklı Formation) were shown in the Medetli section, Gölpazari (Locality 5), Black Sea region (Matsumaru et al. 1996, 1997; Arakawa et al. 2003) (Text-figure 8), and $^{87}Sr/^{86}Sr$ values and element profiles of the Akveren Formation were shown in the Devrekani section, Kastamonu (Locality 8), Black Sea region (Matsumaru et al. 1996, 1998) (Text-figure 9). The non-occurrence of foraminifers and the effect of low foraminiferal diversity were existed into and above the K-T boundary layers, respectively. The K-T boundary layers (Ir and goethite layers) in the Black Sea region (Localities 5, 8-10) are well correlated with those (Ir and limonite layers) of the top Mahadeo Formation at the Um Sohryngkew River section, Meghalaya, NE India (Pandey 1981, 1990; Bhandari et al. 1987, 1994; Garg and Jain 1995; Murali et al. 1990).

## STRATIGRAPHY, LITHOLOGY, FAUNAL SUCCESSION AND CORRELATION

The geology of Turkey has developed by complex convergence of various micro-plates between the Eurasian Plate in the north and the Menderes-Tauride Platform and Arabian Platform in the




TEXT-FIGURE 1
Map showing locations of the study area of both the Haymana region, south of Ankara, and Black Sea region of Pontides and Sakarya zones of main tectonic units of Turkey (after Matsumaru et al. 1996, fig. 1; Matsumaru et al. 2010, text-fig. 1). Sample locality 734 of Bolu, Black Sea region (Sirel 1995, fig.1) is shown for study.

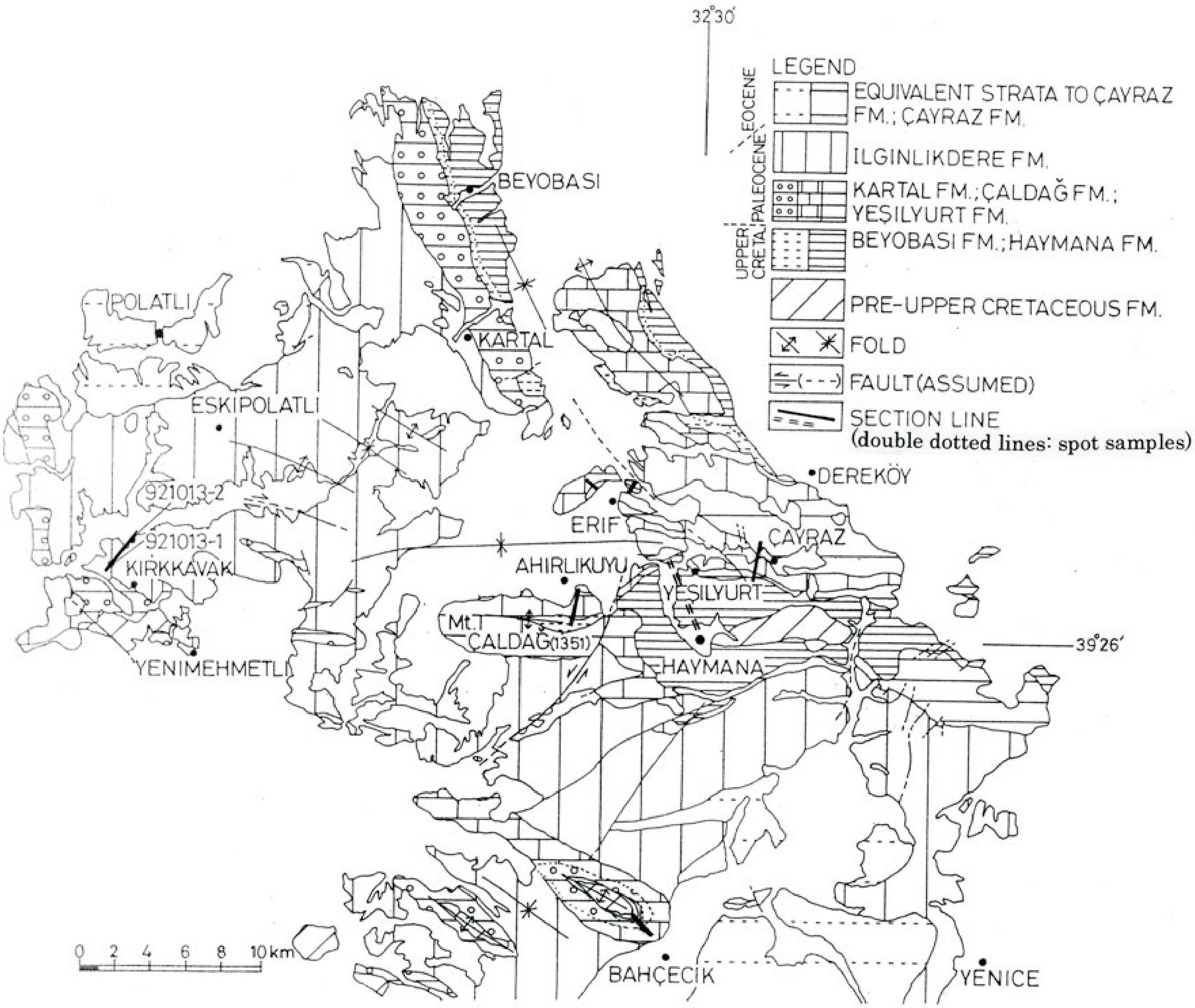
south (Matsumaru et al. 1996; Matsumaru et al. 2010, text-fig. 1). The diverse entities of micro-continent collage are represented by numerous suture zonal complexes, island arcs, marginal basins and others, and are thought to have been amalgamated to form an Alpine orogeny. Then, two diverse Haymana and Black Sea regions are treated in this study (Text-figure 1).

**Haymana region**

The upper Cretaceous to middle Eocene rock sequences of the Haymana region are developed into the western and eastern two local areas. The sedimentary rocks in both two areas are tectonically highly distributed by foldings and faults under the influence of general characters of North-South collision belts between the Eurasian Plate and Menderes-Taurus Platform as stated above (Matsumaru et al. 2010, text-fig. 1) (Text-figure 2). The main route was mainly selected according to several field trips of IGCP No. 286, third Meeting, Ankara, 1992 (M. T. A. 1992; Sirel 1992).

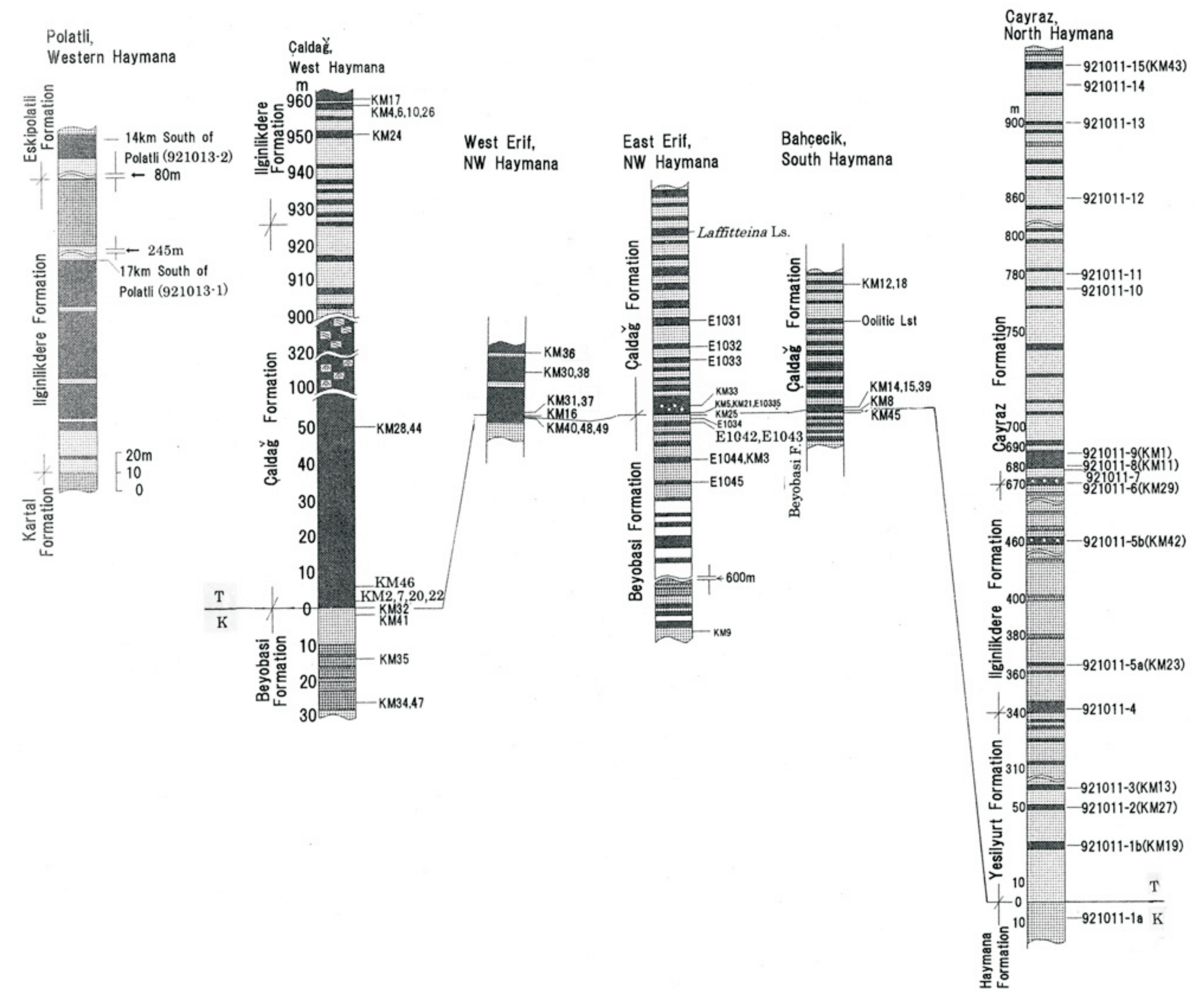
In the western Haymana, the late Cretaceous (Maastrichtian) Beyobashi Formation (composed mainly of yellow coloured sandstone, conglomerate, marl and sandy limestone), early Paleocene Kartal Formation (composed of fluvial red coloured sandstone and conglomerate), which is laterally toward eastern areas changing with the shallow marine Çaldağ Formation (composed of light gray to gray coloured limestone), late Paleocene Ilginlikdere Formation (composed of alternation of yellow coloured coarse grained sandstone and sandy limestone and/or marl, and conglomerate) and early Eocene Eskipolatli Formation (composed of sandstone and limestone) are widely developed (Ünalan et al. 1976) (Text-figures 2, 3). The five sections of Polatli (Kirkkavak), Çaldağ, west Erif, east Erif, and Bahçecik localities are selected in the western Haymana for the detailed larger foraminiferal biostratigraphy.

In the Çaldağ section, samples were collected on the northern hill (north wing of Çaldağ Anticline) (Text-figures 2-3). The upper Beyobasi Formation (samples KM34, KM47, KM35 and KM41) yields *Hellenocyclina beotica* Reichel, *Kathina* sp. A, *Lepidorbitoides minor* (Schlumberger), *L. socialis* (Leymerie), *L.* spp., *Mississippina binkhorsti* (Reuss), *Omphalocyclus macroporus* (Lamarck), *Orbitoides apiculata* Schlumberger, *O. gruenbachensis* Papp, *O. media* (d'Archiac), *O. megaloformis* Papp and Küpper, *O. tissoti* Schlumberger, *O.* spp., *Planorbulina cretae* (Marsson), *Planorbulinella dordoniensis* Hofker, *Pseudosiderolites vidali* (Douvillé), *Siderolites calcitrapoides* Lamarck, *Simplorbites papyraceus* Boubée, *Sirtina*



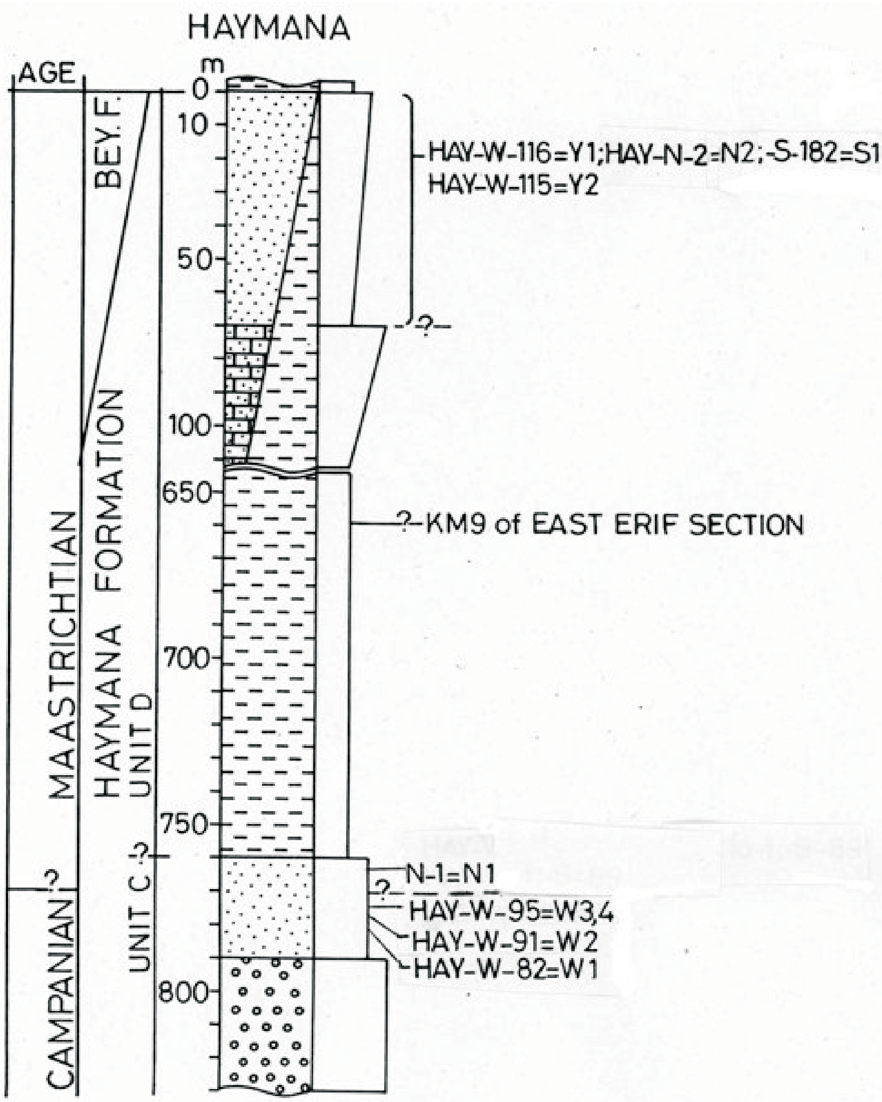

TEXT-FIGURE 2
Geological map of the Haymana region, Turkey in this study with minor revision (Unalan et al. 1976; Geological map of Ankara -1:500,000, 1975; Sirel 1992, fig. 1) is showing the locations of the measured columnar sections from Polatli (Kirkkavak), western Haymana; Çaldağ, west Haymana; west and east Erif, NW Haymana; Bahçeck, south Haymana; and Çayraz, north Haymana. The main rout of and around Haymana (Özcan and Özcan Altiner 1992, fig. 1; double dotted lines) is shown for the re-examination in this study.

*orbitoidiformis* Brönnimann and Wirz, *Sulcoperculina dickersoni* (Palmer), *Chrysalidina* spp., *Loftusia ketini* Meriç, *Monchalmontia apenninica* De Castro, *Navarella joaguini* Ciry and Rat, *Pseudolituonella* spp., *Textularia* spp., *Idalina antiqua* Munier-Chalmas and Schlumberger, *Keramosphaerina* spp., and *Pseudedomia hamaouii* Rahaghi (Text-figure 5A). This fauna is assigned to the Assemblage 3 due to common occurrences of *Orbitoides apiculata, Lepidorbitoides socialis, Siderolites calcitrapoides* and *Navarella joaguini.* Also two samples KM47 and KM35 yield the planktonic foraminifera, *Hedbergella* spp., *Globotruncana falsostuarti* Sigal, *G.* spp., *Globotruncanita* cf. *subspinosa* (Passagno), *Globotruncanella* spp. and *Rugoglobigerina rugosa* (Plummer) (Text-figure 6A). These species indicate the Zone KS31 or *Abathomphalus mayoroensis* zone (Sliter 1989; Caron 1985; Postuma 1971). This zone is correlative with Sirel (1992, p. 5-6, fig. 4)'s Maastrichtian Assemblage I due to occurrence of *Siderolites calcitrapoides*, *Omphalocyclus macroporus* and *Loftusia elongate* Cox. The basal Çaldağ Formation (sample KM32) yields *Anomalinoides rubiginosus* (Cushman), *Laffitteina bibensis* Marie, *Mississippina binkhorsti, *Sulcoperculina dickersoni, Chrysalidina* spp., **Minouxia* spp., **Moncharomontia appenninica* (De Castro), *Pseudolituonella* spp., *Textularia* spp., *Idalina sinjarica* Grimsdale, **Opthalmidium* spp., **Rhapydionina librunica* Stache and *Scandonea samnitica* De Castro (Text-figure 5A). Asterisk five species are reworked. The present fauna is assigned to the Assemblage 6 due to common occurrences of *Laffitteina bibensis, Idalina sinjarica, Mississippina binkhorsti* and *Scandonea samnitica.* This fauna may partial be correlated with the Thanetian Assemblage III




TEXT-FIGURE 3
Map is showing the columnar sections of Polatli (Kirkkavak), western Haymana; Çaldağ, west Haymana; west and east Erif, NW Haymana; Bahçecik, south Haymana; and Çayraz, north Haymana, all of the Haymana region. The upper Cretaceous (K) Beyobashi and Haymana Formations, and Tertiary (Paleogene, T) Ilginlikdere, Eskipolatli, Çaldağ, Yesilyurt, and Çayraz Formations are shown with sampling stations in the columnar sections.

(Sirel 1992, fig. 4) due to occurrence of *Planorbulina cretae, Laffitteina mengaudi* (Astre), *Scandonea* sp. and *Miscellanea primitiva* Rahaghi. According to Sirel (1999), the *Haymanella* Sirel (type species, *H. paleocenica*) and *Kayseriella* Sirel (type species, *K. decastroi*) occur from the Danian Çaldağ Limestone (Assemblage I of Sirel 1992), but there is unkown of Danian planktonic foraminifera. The Assemblage 6 in this study is correlated with the fauna of the basal Çaldağ Formation (samples E1033.5, KM5, KM21 and KM33) in the east Erif section, NW Haymana, as stated later, due to common occurrences of *Laffitteina bibensis, Mississippina binkhorsti, Idalina sinjarica* and *Scandonea samnitica* (text-figure 5A). In addition, samples E1033.5 and KM5 yield the planktonic foraminifera, *Subbotina* spp., which is similar to *S. triloculinoides* (Plummer), and *Parasubbotina trinidadensis* (Bolli), *Morozovella* spp. and **Rugoglobigerina rugosa* (Plummer) (Text-figure 6A), and these species except asterisk species indicate the Zone P2 (Blow 1969; Postuma 1971; Berggren and Van Couvering 1974; Toumarkine and Luterbacher 1985; Berggren et al. 1995). The lower Çaldağ Formation (samples KM2, KM7, KM20, KM22, KM46, KM28 and KM44) in the Çaldağ section yields *Anomalinoides rubiginosus, Assilina dandotica* Davies, *Laffitteina bibensis, Miscellanea globularis* Rahaghi, *M. primitiva*, *Mississippina binkhorsti, Planorbulina cretae* (Marsson), **Planorbulinella dordoniensis, Rotalia trochidiformis* (Lamarck), **Sulcoperculina dickersoni, Chrysalidina* spp., *Pseudochrysalidina* spp., *Pseudolituonella* spp., *Textularia* spp., *Chaldagia haymanensis*, n. gen., n. sp., *Idalina sinjarica*, *Opthalmidium* spp., and *Scandonea samnitica* (Text-figure 5A). Asterisk species are reworked from the Beyobasi Formation. *Assilina dandotica* occur the Ilginlikudere Formation (sample KM23) in the Çayraz section, and this occurrence is considered to be transported (Text-figures 5B, 13). The present fauna is assigned to the Assemblage 7 due to common occurrences of *Miscellanea globularis, M. primitiva*, *Laffitteina bibensis* and *Idalina sinjarica*. Also samples KM 2,




TEXT-FIGURE 4
Map is showing the representative columnar section of the upper Cretaceous Haymana Formation with the same sampling stations by Özcan and Özcan Altiner (1992, fig. 1) along the main route of and around Haymana (double dotted lines of Text-figure 2). Samples are collected by Dr. K. Erdoğan (MTA, Turkey) for the present study. Sample station of sample KM9 of east Erif, NW Haymana (Text-figure 3) is estimated to be about 658 m below the K-T boundary (top Beyobashi Formation; 0 m level).

KM20 and KM46 yield the planktonic foraminifera, *Subbotina* spp., *Parasubbotina pseudobulloides* (Plummer), and *Morozovella* spp. (Text-figure 6A). These species indicate the Zone P3 (Blow 1969; Postuma 1971; Berggren and Van Couvering 1974; Toumarkine and Luterbacher 1985; Berggren etal. 1995). The present Assemblage 7 is correlated with the *Broeckinella arabica* Henson - *Coskinon rajkae* Hottinger and Drobne – *Idalina sinjarica* Grimsdale – *Miscellanea primitiva* – *Pseudolituonella* sp. (nov.) – *Rotalia trochidiformis* Assemblage (Assemblage 1) from the lower Masungit Limestone (sample 7451105b), Maybangain Formation, Luzon Island and lower limestone of the Barcelona Group, East Mindanao, Philippines due to common occurrences of *Miscellanea primitiva, Idalina sinjarica, Rotalia trochidiformis, Chrysalidina* spp., *Pseudochrysalidina* spp., *Pseudolituonella* spp., *Parasubbotina pseudobulloides, P. trinidadensis* and *Globanomalina compressa* (Matsumaru 2011) (Text-figure 12). The Ilginlikudere Formation (samples KM24, KM4, KM6, KM10, KM26, and KM17) in the Çaldağ section yields *Anomalinoides rubiginousus*, *Miscellanea globularis, M. primitiva, M.* spp., *Mississippina binkhorsti, Orbitosiphon tibeteica* (Douvillé), *Rotalia trochidiformis, Sivasella monolateralis, Chrysalidina* spp., *Pseudochrysalidina* spp., *Valbulina* spp., *Idalina sinjarica, Miliolina* spp., *Opthalmidium* spp., *Peneroplis* spp., *Pseudolacazina donatae* (Drobne) and *Scandonea samnitica* (Text-figure 5A). This fauna is assigned to the Assemblage 8 due to common occurrences of *Orbitosiphon tibetica, Miscellanea globularis, M. primitiva*, and *Idalina sinjarica*. Also samples KM4, KM10 and KM26 yield the planktonic foraminifera, *Acarinina* spp., *Parasubbotina pseudobulloides, P. trinidadensis* (Bolli), *Morozovella* spp., *Globanomalina compressa* (Plummer), *G. pseudomenardii* (Bolli) and *G.* spp. (Text-figure

| Species / Sampling station | KM34 | KM47 | KM35 | KM41 | KM32 | KM2 | KM7 | KM20 | KM22 | KM46 | KM28 | KM44 | KM24 | KM4 | KM6 | KM10 | KM26 | KM17 | 921013-1 | 921013-2 | KM9 | KM3 | E1044 | E1043 | E1034 | KM25 | E1033.5 | KM5 | KM21 | KM33 | E1033 | E1032 | E1031 | KM40 | KM48 | KM49 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Anomalinoides rubiginosus | | | | | X | X | X | X | | X | | | | | | | X | X | | | | | | | | | | X | | X | X | X | X | | X | |
| 2 Assilina cuvillieri | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 A. dandotica | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 A. exponens | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 A. laxispira | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 A. leymeriei | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 A. medanica | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 A. placentula | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 A. pustulosa | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | |
| 10 A. spira | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 A. tenuimarginata | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 A. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 Cuvillierina sireli | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | |
| 14 C. soezerii | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | |
| 15 C. sp. | | | | | | | | | | | | | | | | | | | | | | X | | | | X | X | | | | | | | | | |
| 16 Daviesina danieli | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | X | X | X | | | X | | | |
| 17 D. langhami | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | |
| 18 Dictyokathina simplex | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 19 Discocyclina archiaci | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | |
| 20 D. seunesi | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | |
| 21 D. trabayaensis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 D. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 23 Eorupertia boninensis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24 Hellenocyclina beotica | X | X | X | | | | | | | | | | | | | | | | | | | X | | X | X | X | X | | X | | | | | X | | X |
| 25 Kathina majoa | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | |
| 26 K. selveri | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | |
| 27 K. sp. A | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28 Laffitteina bibensis | | | | | X | | | | | | | X | | | | | | | | | | | | | | | | X | | | X | X | X | | | |
| 29 Lepidorbitoides bisambergensis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 30 L. campaniensis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 31 L. minor | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 32 L. pembergeri | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 33 L. socialis | X | X | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | |
| 34 L. spp. | X | X | X | | | | | | | | | | | | | | | | | | | X | X | X | X | X | X | | X | | | | | | | |
| 35 Lockhartia conditi | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 36 L. haimei | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 37 Miscellanea globularis | | | | | | X | | X | X | | | | X | X | X | X | X | X | | | | | | | | | | X | X | X | | | | | | |
| 38 M. primitiva | | | | | | X | | X | X | X | | | X | | | X | X | X | | | | | | | | | | | | | | | | | | |
| 39 M. spp. | | | | | | | | | | | | | X | | | | | X | | | | | | | | | | | | X | | | | | | |
| 40 Mississippina binkhorsti | | X | X | X | X | | | | | | | | | X | | | | | | | | | | | | | | X | | | X | X | X | | | |
| 41 Nummulites atacicus | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | |
| 42 N. deserti | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 43 N. distans | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 44 N. globulus | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 45 N. irregularis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 46 N. laevigatus | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 47 N. lehneri | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 48 N. partschi | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 49 N. planulatus | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 50 Omphalocyclus macroporus | X | X | X | | | | | | | | | | | | | | | | | | | X | | X | | | X | | | | | | | X | X | |
| 51 Operculina canalifera | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | |
| 52 O. heberti | | | | | | | | | | | | | | | | | | | X | | | | | | | | X | | | | | | | | | |
| 53 Orbitoides apiculata | X | X | | | | | | | | | | | | | | | | | | | | X | | X | | X | X | | X | | | | | X | X | X |
| 54 O. gruenbachensis | X | X | | | | | | | | | | | | | | | | | | | | X | | X | | X | X | | | | | | | X | X | X |
| 55 O. media | X | X | | X | | | | | | | | | | | | | | | | | | X | | X | X | X | | | | | | | | X | X | X |
| 56 O. megaloformis | X | | | | | | | | | | | | | | | | | | | | | X | | X | | X | X | | X | | | | | X | X | X |
| 57 O. tissoti | X | | | | | | | | | | | | | | | | | | | | X | | | | | X | X | | | | | | | X | | X |
| 58 O. spp. | | X | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | |
| 59 Orbitosiphon tibetica | | | | | | | | | | | | | | X | | X | X | | | | | | | | | | | | | | | | | | | |
| 60 Planorbulina cretae | | X | | | | X | | X | | | | | | | | | | | | | | | | | | | | | | X | X | X | | | | |
| 61 Planorbulinella dordoniensis | | X | X | | | X | | | | | | | | | | | | | | | X | | X | | | | | | | X | | | | | | |
| 62 Pseudomphalocyclus blumenthali | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | |
| 63 Pseudorbitoides trechmanni | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | |
| 64 Pseudosiderolites vidali | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 65 Ranikothalia nuttalli | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 66 Rotalia trochidiformis | | | | | | X | | | | X | | | | | | X | X | | X | | | | | | | | | | | X | | | | | | |
| 67 Siderolites calcitrapoides | X | X | X | | | | | | | | | | | | | | | | | | X | X | | X | X | X | X | | X | | | | | X | | X |
| 68 Simplorbites papyraceus | X | X | | | | | | | | | | | | | | | | | | | | | | | | X | X | | X | | | | | X | X | X |
| 69 Sirtina orbitoidiformis | | X | X | | | | | | | | | | | | | | | | | | X | | | X | X | X | X | | X | | | | | X | X | |
| 70 Sistanites iranica | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | X | | | |
| 71 Sivasella monolateralis | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 72 Sulcoperculina dickersoni | | X | X | X | X | X | | X | X | | | | | | | | | | | | X | | X | | | X | X | X | X | | X | | | | | |
| 73 Sulcorbitoides pardoi | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | |
| 74 Chrysalidina spp. | X | X | X | | X | X | X | X | X | | X | X | X | X | X | X | X | X | | | | | | | | | | X | X | X | X | X | X | | | |
| 75 Coskinon rajkae | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | |
| 76 Loftusia ketini | X | X | X | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | X | X | X |
| 77 Minouxia spp. | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 78 Moncharomontia apenninica | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 79 Navarella joaguini | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 80 Praechrysalidina spp. | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 81 Pseudochrysalidina spp. | | | | | | X | | | | X | | | X | | | | | X | | | | | | | | | | | X | | | | | | | |
| 82 Pseudolituonella spp. | | X | | | X | X | X | X | | | | | | | | | | | | | | | | | | X | X | X | X | | X | | | | | |
| 83 Textularia spp. | | X | | | X | | | X | | X | | | | | | | | | | | X | | | | | | | X | | X | | X | X | | | X |
| 84 Valvulina spp. | | | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | X | X | | | | |
| 85 Alveolina canavarii | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | |
| 86 A. oblonga | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 87 A. vredenburgi | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | |
| 88 A. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 89 Chaldagia haymanensis,n.gen.,n.sp. | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 90 Idalina antiqua | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 91 I. sinjarica | | | | | X | | X | X | X | X | X | X | X | X | X | X | X | | | | | | | | | | X | X | X | X | X | X | X | | | |
| 92 Keramosphaerina spp. | X | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | |
| 93 Miliolina spp. | | | | | | | | | | | | | | X | | X | X | | | | | | | | | | | X | | X | | X | | | | |
| 94 Nummofallotia cretacea | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | |
| 95 Opthalmidium spp. | | | | | X | | | X | | | | | X | | | X | X | X | | | | | | | | | | | | | | | | | | |
| 96 Orbitolites complanatus | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 97 Peneroplis spp. | | | | | | | | | | | | | X | X | X | X | X | | | | | | | | | | | | | | | | | | | |
| 98 Pseudedomia hamaouii | | | X | | | | | | | | | | | | | | | | | | X | | | | | X | X | | X | | | | | | | |
| 99 Pseudolacazina donatae | | | | | | | | | | | | | X | | | X | X | | | | | | | | | | | | | | | | | | | |
| 100 Rhapydionina librunica | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 101 Scandonea samnitica | | | | | X | X | X | X | | X | | | | | | X | | | | | | | | | | | | X | | X | | | X | | | |

TEXT-FIGURE 5A
Distribution chart of larger benthonic foraminifera from the Beyobashi, Çaldağ, Ilginlikdere and Eskipolatli Formations in Çaldağ, west Haymana; Polatli (Kirkkavak), western Haymana; and west and east Erif, NW Haymana, all of the Haymana region (Text-figures 2, 3).

| Species \ Sampling station | KM31 | KM37 | KM30 | KM38 | KM36 | KM45 | KM8 | KM14 | KM15 | KM39 | KM12 | KM18 | 921011-1a | KM19 | KM27 | KM13 | 921011-4 | KM23 | KM42 | KM29 | 921011-7 | KM11 | KM1 | 921011-10 | 921011-11 | 921011-12 | 921011-14 | KM43 | W 1 | W 2 | W 3 | W 4 | N 1 | Y 2 | Y 1 | N 2 | S 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Anomalinoides rubiginosus | X | X | X | X | X | | | X | X | | | | | | X | | | | | | | | | | | | | | | | | | X | | X | X | |
| 2 Assilina cuvillieri | | | | | | | | | | | | | | | | | | | | | | X | X | X | X | X | X | X | | | | | | | | | |
| 3 A. dandotica | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | |
| 4 A. exponens | | | | | | | | | | | | | | | | | | | | | | X | | | | | X | X | | | | | | | | | |
| 5 A. laxispira | | | | | | | | | | | | | | | | | | | | | | X | X | X | | X | | | | | | | | | | | |
| 6 A. leymeriei | | | | | | | | | | | | | | | | | | X | | X | X | | | | | | | | | | | | | | | | |
| 7 A. medanica | | | | | | | | | | | | | | | | | | | | | | | | | X | | | X | | | | | | | | | |
| 8 A. placentula | | | | | | | | | | | | | | | | | | X | | X | | X | X | X | X | X | | | | | | | | | | | |
| 9 A. pustulosa | | | | | | | | | | | | | | | | | X | X | X | | | | | | | | | | | | | | | | | | |
| 10 A. spira | | | | | | | | | | | | | | | | | | | | | | X | | X | X | X | X | | | | | | | | | | |
| 11 A. tenuimarginata | | | | | | | | | | | | | | | | | | | | | | X | | X | X | X | X | X | | | | | | | | | |
| 12 A. spp. | | | | | | | | | | | | | | | | | | | | | | X | X | | X | | | | | | | | | | | | |
| 13 Cuvillierina sireli | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 C. soezerii | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 C. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 16 Daviesina danieli | | | X | | | | | X | | | X | X | | | | | | | | X | | X | X | X | X | | | X | | | | | | | | | |
| 17 D. langhami | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 Dictyokathina simplex | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 Discocyclina archiaci | | | | | | | | | | | | | | | | | | | | X | | | X | | | | | | | | | | | | | | |
| 20 D. seunesi | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | |
| 21 D. trabayaensis | | | | | | | | | | | | | | | | | | | | | | X | | | X | | | | | | | | | | | | |
| 22 D. spp. | | | | | | | | | | | | | | | | | | | | X | X | X | | | | X | X | | | | | | | | | | |
| 23 Eorupertia boninensis | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | |
| 24 Hellenocyclina beotica | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25 Kathina majoa | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | |
| 26 K. selveri | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | |
| 27 K. sp. A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28 Laffitteina bibensis | | | X | X | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | |
| 29 Lepidorbitoides bisambergensis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | |
| 30 L. campaniensis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | |
| 31 L. minor | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 32 L. pembergeri | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | |
| 33 L. socialis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 34 L. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | X |
| 35 Lockhartia conditi | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | |
| 36 L. haimei | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | |
| 37 Miscellanea globularis | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | |
| 38 M. primitiva | | | X | X | X | | | | | | X | X | | | X | X | | | | | | | | | | | | | | | | | | | | | |
| 39 M. spp. | | | | | X | | | X | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | |
| 40 Mississippina binkhorsti | | | X | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | X | X | |
| 41 Nummulites atacicus | | | | | | | | | | | | | | | | | | | X | X | X | X | | | | X | | X | | | | | | | | | |
| 42 N. deserti | | | | | | | | | | | | | | | | | X | X | X | | | | | | | | | | | | | | | | | | |
| 43 N. distans | | | | | | | | | | | | | | | | | | | | | | X | X | X | X | | | | | | | | | | | | |
| 44 N. globulus | | | | | | | | | | | | | | | | | | X | | X | | X | | | | | | | | | | | | | | | |
| 45 N. irregularis | | | | | | | | | | | | | | | | | | | | X | | X | X | X | | | | | | | | | | | | | |
| 46 N. laevigatus | | | | | | | | | | | | | | | | | | | | | | X | X | X | X | X | X | X | | | | | | | | | |
| 47 N. lehneri | | | | | | | | | | | | | | | | | | | | | | X | X | | | X | X | X | | | | | | | | | |
| 48 N. partschi | | | | | | | | | | | | | | | | | | | | X | | X | X | X | X | | | | | | | | | | | | |
| 49 N. planulatus | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | |
| 50 Omphalocyclus macroporus | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X |
| 51 Operculina canalifera | | | | | | | | | | | | | | | | | | X | X | X | | X | | | | | | | | | | | | | | | |
| 52 O. heberti | | | | | | | | | | | | | | | | | | | | | | X | | | | | X | X | | | | | | | | | |
| 53 Orbitoides apiculata | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 54 O. gruenbachensis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | |
| 55 O. media | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | X | | | | X | | | | X |
| 56 O. megaloformis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | |
| 57 O. tissoti | | | | | | X | | X | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 58 O. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 59 Orbitosiphon tibetica | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 60 Planorbulina cretae | | | | | | X | | X | | | | | | | | | | | | | | | | | | | | | | | | X | | X | X | | |
| 61 Planorbulinella dordoniensis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 62 Pseudomphalocyclus blumenthali | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 63 Pseudorbitoides trechmanni | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | X | | | | | | |
| 64 Pseudosiderolites vidali | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 65 Ranikothalia nuttalli | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | |
| 66 Rotalia trochidiformis | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | |
| 67 Siderolites calcitrapoides | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X |
| 68 Simplorbites papyraceus | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 69 Sirtina orbitoidiformis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 70 Sistanites iranica | | | | X | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | |
| 71 Sivasella monolateralis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | X |
| 72 Sulcoperculina dickersoni | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | X | X | X | | | | | | |
| 73 Sulcoperculina pardoi | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 74 Chrysalidina spp. | X | X | X | X | | | | X | | X | | | | | X | X | | | | | | | | | | | | | | | | | | | | X | |
| 75 Coskinon rajkae | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 76 Loftusia ketini | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 77 Minouxia spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | |
| 78 Moncharomontia apenninica | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 79 Navarella joaguini | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 80 Praechrysalidina spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 81 Pseudochrysalidina spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 82 Pseudolituonella spp. | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | X | | | | X | | | | |
| 83 Textularia spp. | | X | | | | | | | | X | | | | | X | | | | | | | | | | | | | | | | X | | X | | X | X | |
| 84 Valvulina spp. | | | | X | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 85 Alveolina canavarii | | | | | | | | | | | | | | | | | | | | X | X | X | X | X | | | X | X | | | | | | | | | |
| 86 A. oblonga | | | | | | | | | | | | | | | | | | | | X | X | X | X | X | | | | | | | | | | | | | |
| 87 A. vredenburgi | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 88 A. spp. | | | | | | | | | | | | | | | | | | | | X | | X | | X | | | | X | | | | | | | | | |
| 89 Chaldagia haymanensis,n.gen.,n.sp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 90 Idalina antiqua | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 91 I. sinjarica | | X | X | X | X | | | X | | X | X | X | | | X | X | | | | | | | | | | | | | | | | | | | | | |
| 92 Keramosphaerina spp. | | | | | | | | | | | | | | | | | | | | | | X | | | | | | X | | | | | | | | | |
| 93 Miliolina spp. | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 94 Nummofallotia cretacea | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 95 Opthalmidium spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | |
| 96 Orbitolites complanatus | | | | | | | | | | | | | | | | | | | | X | | X | | | | X | X | X | | | | | | | | | |
| 97 Peneroplis spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 98 Pseudedomia hamaouii | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | |
| 99 Pseudolacazina donatae | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 100 Rhapydionina librunica | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 101 Scandonea samnitica | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | |

TEXT-FIGURE 5B
Distribution chart of larger benthic foraminifera from the Beyobashi, Haymana, Çaldağ, Yesilyurt, Ilginlikdere, and Çayraz Formations in west Erif, NW Haymana; Bahaçecik, south Haymana; Çayraz, north Haymana; and the main route of and around Haymana (Text-figures 2, 3).

| Species / Sampling station | KM34 | KM47 | KM35 | KM41 | KM32 | KM2 | KM7 | KM20 | KM22 | KM46 | KM28 | KM44 | KM24 | KM4 | KM6 | KM10 | KM26 | KM17 | 921013-1 | 921013-2 | KM9 | KM3 | E1044 | E1043 | E1034 | KM25 | E1033.5 | KM5 | KM21 | KM33 | E1033 | E1032 | E1031 | KM40 | KM48 | KM49 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Acarinina spp. | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 2 Globoconusa ex gr. G. daubjergensis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 Subbotina triloculinoides | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 S. spp. | | | | | | X | | X | | | | | | | | | | | | | | | | | | | X | | | | | | | | | |
| 5 Parasubbotina pseudobulloides | | | | | | X | | | | X | | | | | | | X | | | | | | | | | | | | | | | | | | | |
| 6 P. trinidadensis | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | | | | | X | | | | |
| 7 Praemurica ex gr. P. uncinata | | | | | | | | | | | | | | | | | | | | | | | | | | | ? | | | | | | | | | |
| 8 Morozovella angulata | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 M. aequa | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 M. spp. | | | | | | | | X | | | | | | | | X | | | | | | | | | | | | X | | | | | | | | |
| 11 Globanomalina compressa | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 12 G. pseudomenardii | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 13 G. spp. | | | | | | | | | | | | | | X | | X | | | | | | | | | | | | | | | | | | | | |
| 14 Igorina pusilla | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 Hedbergella spp. | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | |
| 16 Heterohelix spp. | | X | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | |
| 17 Guembelitria cretacea | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 Globotruncana arca | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | |
| 19 G. falsostuarti | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 G. spp. | | X | | | | | | | | | | | | | | | | | | | | | X | X | | X | | | X | | | | | | X | |
| 21 Globotruncanita elevata | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 G. stuartiformis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | |
| 23 G. cf. subspinosa | | X | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | | | |
| 24 G. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25 Globotruncanella spp. | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 26 Abathomphalus mayaroensis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27 Rugoglobigerina rugosa | | | X | | | | | | | | | | | | | | | | | | | | X | | | X | X | | X | | | | | | | |
| 28 R. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 29 Rugotruncana subpenny | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | |
| 30 R. spp. | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | |

TEXT-FIGURE 6A
Distribution chart of planktonic foraminifera from the same formations (Text-figure 5A) in the Haymana region.

6A). These species indicate the Zone P4 (Blow 1969; Berggren and Van Couvering 1974; Toumarkine and Luterbacher 1985; Berggren et al. 1995). The present Assemblage 8 is correlated with the *Idalina sinjarica - Miscellanea primitiva - M. miscella - Kathina selveri - Lockhartia diversa* Assemblage (Assemblage 1) and *Aberisphaera gambanica – Daviesina khatiyahi – Lockhartia haimei - Miscellanea miscella – Ranikothalia nuttalli* Assemblage (Assemblage 2) from the middle to late Paleocene Lakadong Limestone, Meghalaya, NE India due to common occurrences of *Idalina sinjarica*, *Miscellanea primitiva, Rotalia trochidiformis, Orbitosiphon tibetica, Pseudochrysalidina* spp. and *Pseudolituonella* spp. (Matsumaru and Sarma 2010) (Text-figure 12). Also, Assemblage 8 is correlated with the *Daviesina danieli – Kathina selveri – Orbitoclypeus ramaraoi – Lockhartia haimei – Miscellanea miscella – Ranikothalia nuttalli – Alveolina vredenburgi* Assemblage (Assemblage 2) from the middle to late Paleocene lower Masungit Limestone (sample 7451105a), Maybangain Formation, Luzon Island, Philippines; lower Sula Formation, Cagraray Island, Philippines; and Talutunan-Tumicob Formation, Marinduque Island, Philippines, based on common occurrences of *Miscellanea globularis, M. primitiva, Rotalia trochidiformis, Parasubbotina* ex gr. *P. pseudobulloides, P. trinidadensis, Globanomalina compressa, Igorina pusilla* (Bolli) and *Acarinina mckannai* (White) (Matsumaru 2011) (Text-figure 12).

The Polatli (Kirkkavak) section (Text-figures 2, 3), sample 921013-1 of the Ilginlikdere Formation, which conformably overlies the Kartal Formation, about 25 km western extension of the Çaldağ section, yields *Daviesina danieli* Smout, *Discocyclina archiaci* (Schlumberger), *D. seunesi* Douvillé, *Operculina canalifera* d'Archiac, *O. heberti* Munier-Chalmas and *Rotalia trochidiformis* (Text-figure 5A). This fauna is assigned to the Assemblage 8 due to occurrences of *Rotalia trochidiformis,* and is traced the same biostratigraphic horizon with the Ilginlikdere Formation carrying Assemblage 8 in the Çaldağ section. The Eskipolatli Formation (sample 921013-2), which is placed at about 345 m higher horizon than the Ilginlikdere Formation (sample 921013-1), yields *Assilina pustulosa* Doncieux, **Daviesina danieli, Discocyclina archiaci*, *Nummulites atacicus* Leymerie, *Alveolina canavari* Checchia-Rispoli and *A. *vredenburgi* Davies (Text-figure 5A). Asterisk species occur as reworked, because they don't yield with *Nummulites atacicus* (Matsumaru and Sarma 2010; Matsumaru 2011). This fauna is assigned to the Assemblage 9 due to common occurrences of *Assilina pustulosa* and *Nummulites atacicus*. The present Assemblage 9 is correlated with the *Alveolina oblonga – A. schwageri – Assilina laxispira – A. placentula* Assemblage (Assemblage 3-1) from the early Eocene Umlatdoh Limestone (samples L2C41 to L2C62), Meghalaya, NE India (Matsumaru and Sarma 2010, text-fig. 2b), and the *Alveolina subpyrenaica – Nummulites atacicus – N. burdigalensis – N. globulus – N. millecaput – Opertorbitolites douvillei* Assemblage (Assemblage 3) from the early Eocene upper Masungit Limestone (sample 7451215), Maybangain Formation, Luzon Island, Philippines, due to common occurrences of *Nummulites atacicus* (Matsumaru 2011) (Text-figure 12).

In the **west** Erif section (Text-figures 2, 3), the Beyobasi Formation (sample KM40, KM48 and KM49) yields *Anomalimoides*

| Species / Sampling statio | KM31 | KM37 | KM30 | KM38 | KM36 | KM45 | KM8 | KM14 | KM15 | KM39 | KM12 | KM18 | 921011-1a | KM19 | KM27 | KM13 | 921011-4 | KM23 | KM42 | KM29 | 921011-7 | KM11 | KM1 | 921011-10 | 921011-11 | 921011-12 | 921011-14 | KM43 | W 1 | W 2 | W 3 | W 4 | N 1 | Y 2 | Y 1 | N 2 | S 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Acarinina spp. | | | | | | | | | | | | | | | | | | X | | | | | | | | | | X | | | | | | | | | |
| 2 Globoconusa ex gr. G. daubjergensis | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | |
| 3 Subbotina triloculinoides | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | |
| 4 S. spp. | | | | | | | | | | | | | | X | | X | | X | | | | | | | X | | | | | | | | | | | | |
| 5 Parasubbotina pseudobulloides | | | | | | | | | | | X | X | | X | | X | | | | | | | | | | | | | | | | | | | | | |
| 6 P. trinidadensis | | | | | | | | | | | X | X | | X | | | | | | | | | | | | | | | | | | | | | | | |
| 7 Praemurica ex gr. P. uncinata | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | |
| 8 Morozovella angulata | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | |
| 9 M. aequa | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | |
| 10 M. spp. | | | X | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | |
| 11 Globanomalina compressa | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 G. pseudomenardii | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 G. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 Igorina pusilla | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | |
| 15 Hedbergella spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | |
| 16 Heterohelix spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | |
| 17 Guembelitria cretacea | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | |
| 18 Globotruncana arca | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 G. falsostuarti | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 G. spp. | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | |
| 21 Globotruncanita elevata | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 G. stuartiformis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | X | | | | |
| 23 G. cf. subspinosa | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24 G. spp. | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25 Globotruncanella spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 26 Abathomphalus mayaroensis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X |
| 27 Rugoglobigerina rugosa | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28 R. spp. | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | |
| 29 Rugotruncana subpenny | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 30 R. spp. | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | |

TEXT-FIGURE 6B
Distribution chart of planktonic foraminifera from the same formations (Text-figure 5B) in the Haymana region.

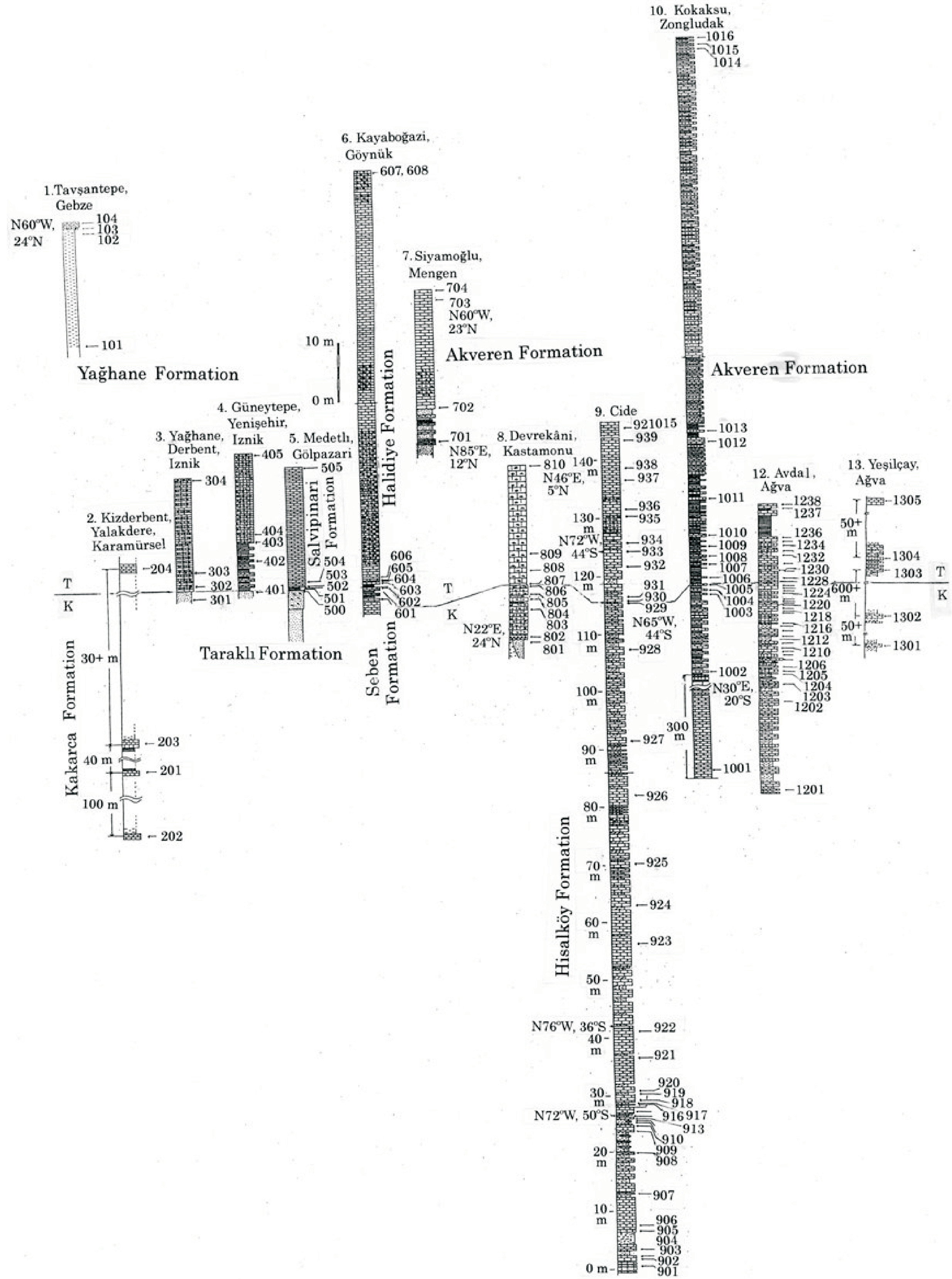
*rubiginosus, Cuvillierina sireli* Inan, *C. soezerii* Sirel, *Hellenocyclina beotica, Omphalocyclus macroporus, Orbitoides apiculata, O. gruenbachensis, O. media, O. megaloformis, O. tissoti, Siderolites calcitrapoides, Simplorbites papyraceus, Sirtina orbitoidiformis, Loftusia ketini* and *Textularia* spp. (Text-figure 5A). This fauna is assigned to the Assemblage 4 due to common occurrences of *Orbitoides apiculata, Siderolites calcitrapoides, Loftusia ketini, Hellenocyclina beotica* and *Omphalocyclus macropolus.* Then, Assemblage 4 lacks *Planorbulinella dordoniensis, Moncharomontia apenninica, Navarella joaguini* and *Idalina antiqua.* Also, sample KM48 yields the planktonic foraminifera, *Globotruncana* spp. and *Globotruncanita stuartiformis* (Dalbiez) (Text-figure 6A). These species indicate the Zone KS31 or *Abathomphalus mayaroensis* zone (Sliter 1989; Caron 1985; Postuma 1971). This is correlated with Sirel (1992, p. 1, fig. 2)'s Maastrichtian Assemblage I due to occurrence of *Siderolites calcitrapoides, Omphalocyclus macroporus* and *Hellenocyclina beotica*. The lower Çaldağ Formation (samples KM31, KM37, KM30, KM38 and KM36) yields *Anomalinoides rubiginosus, Daviesina danieli, Laffitteina bibensis, Miscellanea primitiva, M.* spp., *Mississippina binkhorsti, Sistanites iranica Rahaghi, Chrysalidina* spp., *Textularia* spp., *Valvulina* spp. and *Idalina sinjarica* (Text-figure 5B). This fauna is assigned to the faunal Assemblage 7, due to common occurrences of *Miscellanea primitiva, Laffitteina bibensis* and *Idalina sinjarica* from the Caldağ Formation (samples KM2 to KM44) in the Çaldağ section. Also, sample KM 30 yields *Morozovella* spp. (Text-figure 6B). This zone is at least correlated with Sirel (1992, fig. 2)'s lower Thanetian Assemblage III due to occurrence of *Laffitteina mengaudi* and ?*Scandonea* sp.

In the east Erif section (Text-figures 2, 3), the lower Beyobasi Formation (sample KM9) yields *Orbitoides tissoti, Planorbulinella dordoniensis, Siderolites calcitrapoides, Sirtina orbitoidiformis, Sulcoperculina dickersoni, Textularia* spp. and *Pseudedomia hamaouii* (Text-figure 5A). This fauna is regarded as the Assemblage 2 due to common occurrences of *Orbitoides tissoti, Siderolites calcitrapoides, Sirtina orbitoidiformis, Sulcoperculina dickersoni* and lack of both *Orbitolina apiculata* and *Lepidorbitoides socialis*, which are representative species of the Assemblage 3. The upper Beyobashi Formation (samples KM3, E1044, E1043, E1034 and KM25) in the east Erif section yields *Cuvillierina* spp., *Hellenocyclina beotica, Lepidorbitoides socialis, L.* spp., *Omphalocyclus macroporus*, *Orbitoides apiculata, O. gruenbachensis, O. media, O. megaloformis, O. tissoti, O.* spp., *linella dordoniensis, Pseudomphalocyclus blumenthali* Meriç, *Pseudorbitoides trechimanni* Douvillé, *Siderolites calcitrapoides, Simplorbites papyraceus, Sirtina orbitoidiformis, Sulcoperculina dickersoni, Loftusia ketini, Pseudolituonella* spp., *Keramosphaerina* spp., *Nummofallotia cretacea* (Schlumberger) and *Pseudedomia hamaouii* (Text-figure 5A). The present fauna is assigned to the faunal Assemblage 3, due to common occurrences of the same fauna such as *Hellenocyclina beotica, Lepidorbitoides socialis, Omphalocyclus macroporus, Orbitoides apiculata, O. tissoti,* *Siderolites calcitrapoides* and *Sirtina orbitoidiformis* from the Beyobasi Formation (samples KM34 to KM41) in the Çaldağ section. Also, samples E1044, E1043, E1034 and KM25 yields the planktonic foraminifera, *Hedbergella* spp., *Heterohelix* spp., *Globotruncana arca* (Cushman), *G.* spp., *Globotruncanita* cf. *subspinosa, Rugoglobigerina rugosa, Rugotruncana subpenny* (Gondolfi) and *Rugotruncana* spp. (Text-figure 6A). These species indicate the Zone KS31 or *Abathomphalus mayaroensis* zone (Sliter 1989; Caron 1985; Postuma 1971), and *G.* cf. *subspinosa* is considered to be reworked from the Campanian beds. This is correlated with the Assemblage I (Sirel 1992, p. 2, fig. 3). The basal Çaldağ Formation (samples E1033.5, KM5, KM21 and KM33) in the east Erif section yields *Anomarinoides rubiginosus*, *Cuvillierina* spp., *Daviesina danieli, D. langhami* Smout, *Dictyokathina simplex* Smout, **Hellenocyclina beotica, Kathina major* Smout, *K. selveri, Laffitteina bibensis, *Lepidorbitoides* spp., *Miscellanea globularis, M.* spp., *Mississippina binkhorsti, *Omphalocyclus macroporus, Operculina heberti, *Orbitoides apiculata, *O. gruenbachensis, *O. megaloformis, *O. tissoti, Planorbulina create, *Planorbuilinella dordoniensis, Rotalia trochidiformis, *Siderolites calcitrapoides, *Simplorbitoides papyraceus, *Sirtina orbitoidiformis, Sistanites iranica, *Sulcoperculina dickersoni, *Sulcorbitoides pardoi, Chrysalidina* spp., *Pseudochrysalidina* spp., *Pseudolituonella* spp., *Textularia* spp., *Valvulina* spp., *Idalina sinjarica, *Keramosphaerina* spp., *Miliolina* spp., **Nummofallotia cretacea*, **Psededomia hamaouii* and *Scandonea samnitica* (Text-figure 5A). Asterisk 16 species are reworked. Also *Dictyokathina simplex* and *Kathina major* are derived from the upper Çaldağ Formation. Then the present fauna is assigned to the Assemblage 6, due to common occurrences of *Laffitteina bibensis, Mississippina binkhorsti, Idalina sinjarica* and *Scandonea samnitica* of the Çaldağ Formation (sample KM32) in the Çaldağ section, west Haymana as stated above. Samples E1033.5 and KM5 yields the planktonic foraminifera, *Subbotina* spp., which is similar to *S. triloculinoides, Parasubbotina trinidadensis, Morozovella* spp., P*raemurica* ex gr. *P. uncinata*?, and *Rugoglobigerina rugosa* (Text-figure 6A), and these species except *R. rugosa* indicate the Zone P2 (Blow 1969; Berggren and Van Couvering 1974; Toumarkine and Luterbacher 1985; Berggren et al. 1995). Further, the lower Çaldağ Formation (samples E1033, E1032 and E1031) in the east Erif section yields *Anomalinoides rubiginosus, Daviesina danieli, Laffitteina bibensis, Mississippina binkhorsti*, *Planorbulina cretae, Sistanites iranica,* **Sulcoperculina dickersoni, Chrysalidina* spp., *Coskinon rajkae* Hottinger and Drobne, *Pseudolituonella* spp., *Textularia* spp., *Valvulina* spp., *Idalina sinjarica, Keramosphaera* spp., *Miliolina* spp., and *Scandonea samnitica* (Text-figure 5A). Asterisk species is reworked from the Beyobasi Formation. The present fauna is assigned to the faunal Assemblage 7, due to common occurrences of *Daviesina danieli, Coskinon rajkae* and *Idalina sinjarica*. Also, sample E1032 yields the planktonic foraminifera, *Parasubbotina trinidadensis* (Text-figure 6A). This species is reworked. This assemblage is at least correlated with the lower Thanetian Assemblage III (Sirel 1992).

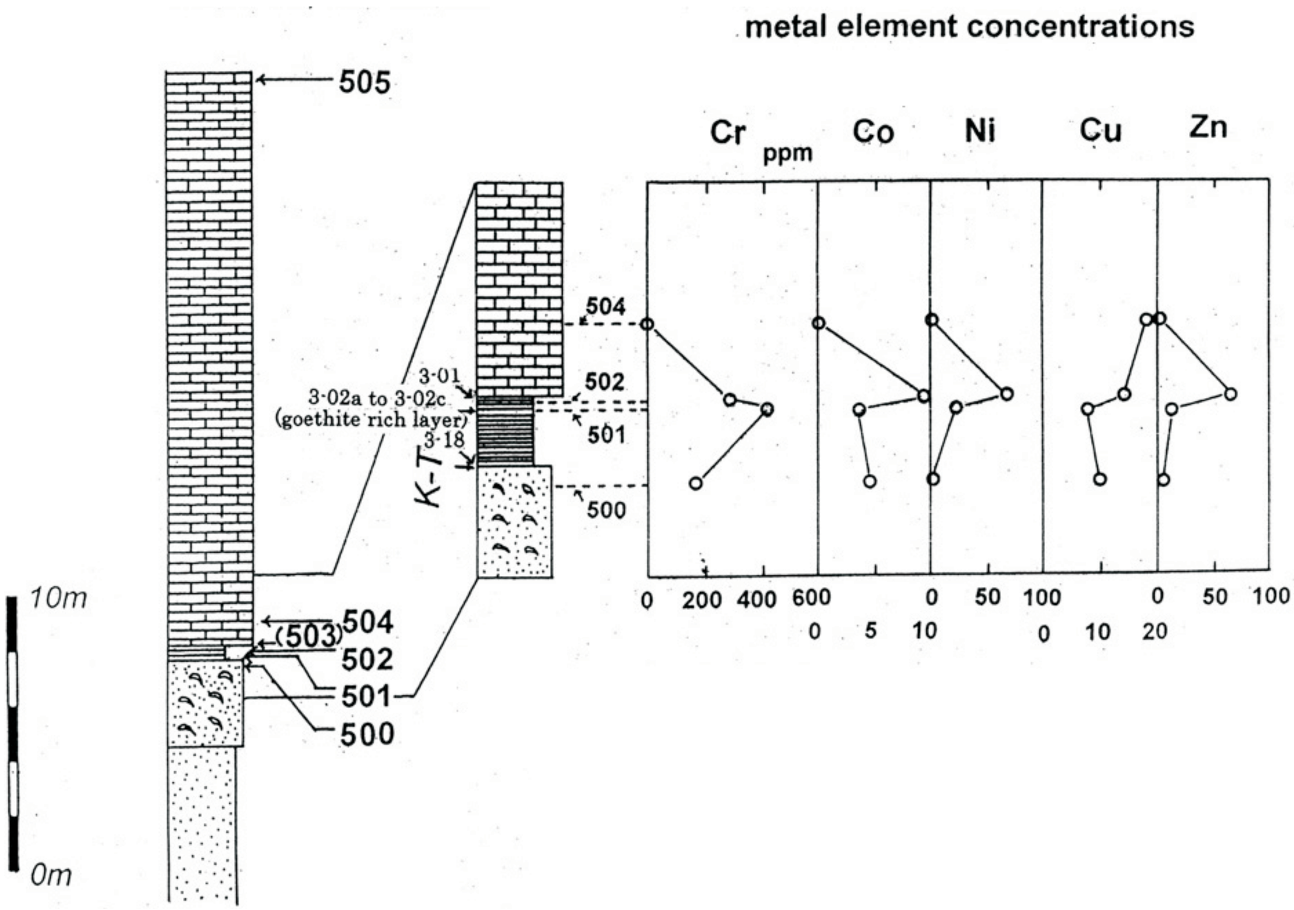
In the Bahçecik section (Text-figures 2-3), the Beyobasi Formation (sample KM45) yields *Omphalocyclus macroporus, Orbitoides media, O. tissoti* and *Planorbulina cretae* (Text-figure 5B). The fauna may be assigned to the Assemblage 3 or Assemblage 4, but is tentatively regarded as Assemblage 4, due to the stratigraphy below the Çaldağ Formation. This is correlated with Sirel (1992, p. 3-4, fig. 5)'s Maastrichtian fauna of *Omphalocyclus macroporus, Siderolites calcitrapoides* and *Hellenocyclina beotica*. The Çaldağ Formation (samples KM8, KM14, KM15, KM39, KM12 and KM18) in the Bahçecik section yields *Anomalinoides rubiginosus, Daviesina danieli,* **Hellenocyclina beotica, Miscellanea primitiva, M.* spp., **Orbitoides tissoti, Pranorbulina cretae, Chrysalidina* spp., *Pseudolituonella* spp., *Textularia* spp., *Valvulina* spp., *Idalina sinjarica,* and *Miliolina* spp. (Text-figure 5B). Asterisk two species are reworked. The present fauna is assigned to the Assemblage 7, due to common occurrences of *Daviesina danieli, Miscellanea primitiva* and *Idalina sinjarica*, and is correlated with the similar fauna from the Çaldağ Formation (samples E1033 to E1031) in the east Erif section. Also, samples KM8, KM12 and KM18 yield the planktonic foraminifera, *Parasubbotina pseudobulloides, P. trinidadensis, *Globotruncanita elevata* (Brotzen), **G.* cf. *subspinosa* and **G.* spp. (Text-figure 6B). Asterisk three species are reworked, and other planktonic foraminiferal species indicate the Zone P3 (Blow 1969; Postuma 1971; Berggren and Van Couvering 1974; Toumarkine and Luterbacher 1985; Berggren et al. 1995). This fauna is at least correlated with Sirel (1992)'s Thanetian fauna of *Miscellanea primitiva* and *M. globularis*.

In the eastern Haymana, The rock sequences in the eastern Haymana are the upper Cretaceous (Campanian – Maastrichtian) Haymana Formation (composed of dark gray coloured marls intercalated with sandstone, conglomerate and sandy limestone), early Paleocene Yesiliyurt Formation (composed of dark gray coloured sandy marl or marly sandstone intercalated with limestone), late Paleocene Ilginlikdere Formation (composed of alternation of gray colored sandy limestone, dark gray colored marl, gray colored sandstone and/or conglomerate) and early to middle Eocene Çayraz Formation (composed of pale yellow and gray coloured sandstone intercalated with limestone and marl) (Ünalan et al. 1996; Toker 1980). Viewing field observations, the author found the lack of outcrop between the Ilginlikdere Formation and Çayraz Formation, and this is considered the effects of environmental condition and tectonic events. Two sections are treated in the eastern Haymana (Text-figures 2-4).

In the Çayraz section (Text-figures 2-3), the Haymana Formation (sample 921011-1a) yields the planktonic foraminidfera *Globotrncana* spp. (Text-figure 6B), but nothing else occurs in this sample. The upper Haymana Formation is correlated with the Beyobasi Formation (Ünalan et al. 1996; Toker 1980). Sirel (1992, p. 8, fig. 6) found the Maastrichtian fauna of *Siderolites calcitrapoides, Omphalocyclus macroporus* and *Hellenocyclina beotica*. The Yesilyurt Formation (samples KM19, KM27 and KM13) in the Çayraz section yields *Anomalinoides rubiginosus, Kathina major, K. selveri, Laffitteina bibensis, Miscellanea globularis, M. primitiva, Rotalia trochidiformis, Sistanites iranica,* **Sulcoperculina dickersoni, Chrysalidina* spp., *Textularia* spp., and *Idalina sinjarica* (Text-figure 5B). Asterisk species is reworked. The present fauna is assigned to the faunal Assembalge 8, based on common occurrences of *Anomalinoides rubiginosus, Kathina selveri, Laffitteina bibensis, Miscellanea globularis, M. primitiva, Sistanites iranica* and *Idalina sinjarica* from the Ilginlikdere Formation (samples KM24 to KM17) in the Çaldağ section, west Haymana. Also, these three samples from the Yesilyurt Formation yield the planktonic foraminifera, *Globoconusa* ex gr. *G. daubjergensis* (Brönnimann), *Subbotina triloculinoides* (Plummer), *S.* spp., *Parasubbotina pseudobulloides, P. trinidadensis,*



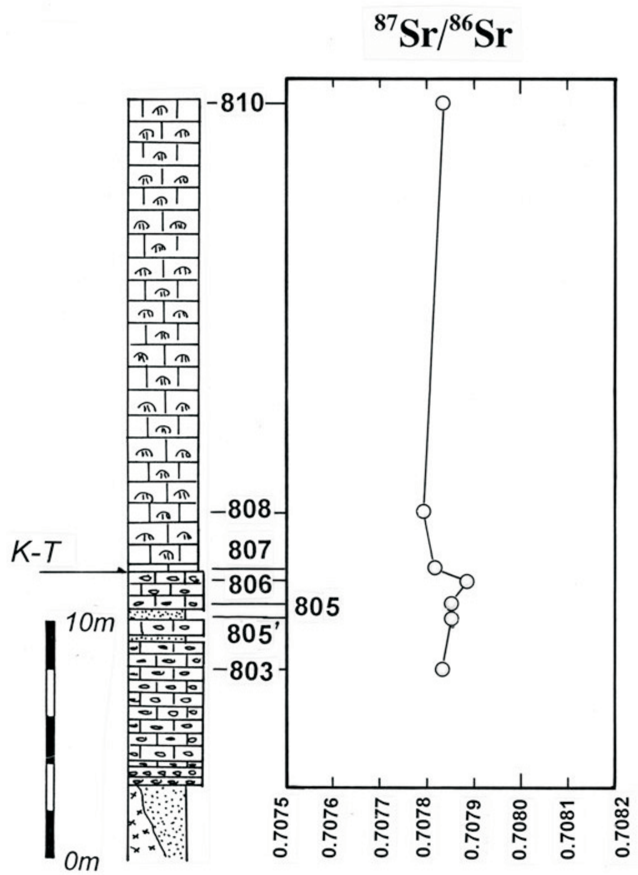

TEXT-FIGURE 7
Columnar sections with sampling stations of the upper Createceous (K) Kakarca, Taraklı and Seben Formations, Paleocene (T) Yaghane, Salvipinari and Halidiye Formations and upper Cretaceous-Paleocene transitional Akveren and Hisarköy Formations, all of the Black Sea region, Turkey are shown in surveyed localities 1 (Tavşantepe, Gebze) to 13 (Yesilcay, Ağva) except point 11 (Sabirli, Alapli) (Text-figure 1).




TEXT-FIGURE 8
Some element concentrations for samples in surveyed locality 5 (Medetlı, Gölpazarı columnar section) in the Black Sea region are shown, and the K-T boundary was considered within the very fine grained sandstone beds (samples 502 and 503) above the upper Cretaceous (Maastrichtian) bivalve *Exogyra*-bearing sandstone of the top Taraklı Formation (Matsumaru et al. 1996, p. 24, fig. 4; Text-figures 1, 7). It is below the Paleocene larger foraminifera *Laffiteina bibensis*-bearing limestone (sample 505) of the Salvipinari Formation. Some siderophile and chalcophile element concentrations (Cr, Co, Ni and Zn) are high and have a peak between samples 501 and 502, and the concentrations were comparable to the results of chemistries for the K-T boundary beds in other regions of the world (Alvarez et al. 1980; Elliot et al. 1994). Ba, Rb and Sr are strongly mobile in a diagenetic and alteration processes, and the peak of elements had to be discussed after the detailed check from various localities (Matsumaru et al. 1996, table 2). Arakawa et al. (2003) in the author's research team could find the Ir concentration in the goethite-rich layers of the shale/sandstone (fine grained sandstone) beds of the top Taraklı Formation (Matsumaru et al. 1997). It was low (0.05-0.10 ppb) in sample 502 and was slightly elevated (0.24 ppb) in sample 501 (= MD-01). At present the author et al.'s team concluded the actual K-T boundary to be situated at the goethite-rich layers between sample 501(MD01) and sample 502 above the *Exogyra*-bearing sandstone (sample 500), all of the Taraklı Formation.

*Praemurica* ex gr. *P. uncinata* (Bolli), *Morozovella angulata* (White), *M. aequa* (Cushman and Renz), *M.* spp., *Igorina pusilla* (Bolli), *Guembelitria cretacea* Cushman, *Rugoglobigerina* spp. and *Rugotruncana subpenny* (Gondolfi) (Text-figure 6B). The first six species and last three species are regarded as reworking. *Morozovella angulata* and *M. aequa* indicate the Zone P4 (Blow 1969; Berggren and Van Couvering 1974; Toumarkine and Luterbacher 1985; Berggren et al. 1995). Sirel (1992, p. 8, fig. 6) found the Thanetian fauna. Also, the Ilginlikdere Formation (samples 921011-4, KM23, KM42, KM29 and 921011-7), which overlies the Yesilyurt Formation in the Çayraz section yields *Assilina dandotica, A. leymerie* d'Archiac and Haime, *A. placentula* (Deshayes), *A. pustulosa* Doncieux, **Daviesina danieli, Discocyclina archiaci* (Schlumberger), *D.* spp., **Lockhartia conditi* (Nuttall), **L. haimei* (Davies), *Nummulites atacicus* Leymerie, *N. deserti* de la Harpe, *N. globulus* Leymerie, *N. irregularis* Deshayes, *N. partschi* de la Harpe, *Operculina canalifera, Alveolina canavalii* Checcia-Rispoli, *A. oblonga* d'Orbigny, *A.* spp., and *Orbitolites complanatus* (Text-figure 5B). Asterisk three species are reworked. In the present fauna, sample 921011-4 from the lower Ilginlikdere Formation yields only two species *Assilina pustulosa* and *Nummulites deserti,* while samples KM29 and 921011-7 from the upper Ilginlikdere Formation yield *Nummulites irregularis* in association with *Assilina leymerie, A. placentula, Nummulites atacicus, N. globulus, N. partchi, Alveolina canavarii, A. oblonga* and *Orbitolites complanatus* (Text-figure 5B). Although there is limited of samples, the present fauna is assigned to the Assemblage 9, due to common occurrences of *Nummulites atacicus, N. globulus, N. partchi, Assilina leymerie, A. pustulosa, Operculina canalifera* and *Orbitolites complanatus*. This fauna is correlated with the *Alveolina oblonga – A. schwageri – Assilina laxispira – A. placentula* Assemblage (Assemblage 3-1) in the Umlatdoh

Limestone, Meghalaya, NE India, due to common occurrences of *N. atacicus, N. globulus* and *O. complanatus* (Matsumaru and Sarma 2010), and the *Alveolina subpyrenaica – Nummulites atacicus – N. burdigalensis – N. globulus – N. millecaput – Opertorbitolites douvillei* Assemblage (Assemblage 3) in the upper Masungit Limestone, Maybangain Formation, Luzon, Philippines, due to common occurrences of *Nummulites atacicus* and *N. globulus* (Matsumaru 2011) (Text-figure 12). Also, sample KM23 in the Çayraz section yields the planktonic foraminifera, *Acarinina* spp. and *Subbotina* spp. (Text-figure 6B). Sirel (1992) found the Ilerdian fauna of *Nummulites praelucasi* Douvillé, *N. exilis* Douvillé, *Alveolina cucumiformis* Hottinger and *Assilina pustulosa* Doncieux. The lower Çayraz Formation (samples KM11, KM1, 921011-10, 921011-11 and 921011-12) in the Çayraz section yields *Assilina cuvillieri* Schaub, *A. exponens* (Sowerby), *A. laxispira* de la Harpe, *A. medanica* Pavlovec, *A. placentula* (Deshayes), *A. spira* (De Roisy), *A. tenuimarginata* Heim, *A*. spp., **Daviesina danieli, Discocyclina archiaci, *D. seunesi, D. trabayaensis* Neumann, *D*. spp., **Miscellanea* spp., *Eorupertia boninensis* (Yabe and Hanzawa), *Nummulites atacicus, Nummulites distans* Deshayes, *N. globulus, N. irregularis, N. laevigatus* (Bruguiere), *N. lehneri* Schaub, *N. partchi, Operculina canalifera, O. heberti, *Ranikothalia nuttalli* Davies, *Alveolina canavali, A. oblonga, A*. spp., **Keramospaerina* spp., and *Orbitolites complanatus* (Text-figure 5B). Asterisk five species are reworked, and *Assilina exponens* and *A. spira* are considered to be transported from the upper Çayraz Formation (Text-figure 13). The present fauna is assigned to the Assemblage 10, due to common occurrences of *Assilina cuvillieri, A. medanica, A. laxispira, A. placentula, Nummulites atacicus, N. globulus, N. distans, N. irregularis, N. laevigatus, N. lehneri, N. partschi*, *Alveolina canavarii*, *A. oblonga* and *Orbitolites complanatus.* This assemblage is correlated with the *Nummulites atacicus – N. globulus* Assemblage (Assemblage 3-2) in the upper Umlatdoh Limestone and *Alveolina elliptica nuttalli – Nummulites beaumonti – N. gizehensis – N. perforatus – Orbitolites complanatus* Assemblage (Assemblage 4-1) in the lower Prang Limestone, both of Meghalaya, NE India (Matsumaru and Sarma 2010), and also correlated with the Assemblage 3 as stated above of the upper Masungit Limestone, Maybangain Formation, Luzon Island (Matsumaru 2011) (Text-figure 12). Also, sample 921011-11 yields the planktonic foraminifera, *Subbotina* spp. (Text-figure 6B). Further, the top Çayraz Formation (samples 921014-14 and KM43) in the Çayraz section yields *Assilina cuvillieri, A. exponens, A. medanica, A. spira, A. tenuimarginata, *Daviesina danieli, Discocyclina* spp., **Nummulites atacicus, N. laevigatus, N. lehneri, *N. planulatus* (Lamarck), **Operculina heberti, *Alveolina canavarii, Alveolina* spp., **Keramosphaerina* spp., and *Orbitolites complanatus* (Text-figure 5B). Asterorisk six species are reworked. The present fauna is assigned to the Assemblage 11 due to common occurrences of *Assilina exponens, A. medanica, A. spira A. tenuimarginata, Nummulites laevigatus, N. lehneri* and *Orbitolites complanatus* (Text-figure 13). This fauna is correlated with the *Nummulites acutus – N. beaumonti - N. gizehensis- N. millecaput – N. perforatus* Assemblage (Assemblage 4-2) of the middle Prang Limestone, Meghalaya, NE India due to common occurrences of *Orbitolites complanatus* (Matsumaru and Sarma 2010) and the *Nummulites gizehensis – N. perforatus – N. ptukhiani – N. striatus – Assilina exponens* Assemblage (Assemblage 4) of the Caraballo Group (sample H502), NE Luzon, and Talutunan-Tumicob Formation, Marinduque Island (sample MQ28), Philippines, due to common occurrences of *Assilina exponens* (Matsumaru 2011) (Text-figure 12). Sample KM43 in the Çayraz section yields the planktonic foraminifera *Acarinina* spp. (Text-figure 6B). Sirel (1992, p. 8-9, fig, 6) found two faunal zones of "*Nummulites atacicus - Assilina placentula - Alveolina canavarii*" fauna and "*Nummulites lehneri - Assilina exponensis*" fauna in the Çayraz section. The former is correlated with the Assemblage 9 to Assemblage 10, while the latter is correlated with the Assemblage 11.




TEXT-FIGURE 9
The $^{87}Sr/^{86}Sr$ ratios of limestone and marl rock samples from two columnar sections (locality 8 Devrekani, Kastamonu, and locality 12 Avdal, Ağva) in the Black Sea region are concentrated in narrow range (0.707752-0.707834) for radiometric age of the K-T transition layers (Matsumaru et al. 1996, p. 32, fig. 3; table 1). This map is showing only the profile of Sr isotope values for samples in surveyed locality 8 Devrekani. The Sr isotope curve and absolute values agree well with data and curve from the other K-T transitional regions of the world (Depaolo and Ingram 1985; Palmer and Elderfield 1985; Macdougall 1988). The K-T boundary exists between beds of samples 806 and 807 of the Akveren Formation. In surveyed locality 12 (Avdal section, Ağva, Text-figure 7), the K-T boundary exist the beds between samples 1226 (Sr value, 0.707769) and 1230 (Sr value, 0.707830) of the Akveren Formation (Matsumaru et al. 1996, p. 32, tab. 1), and is more strictly put in the beds between samples 1227 and 1228, due to occuerrences of *Globotruncanita stuarti, Parvulalgoglobigerina* ex gr. *P. eugubina, Eoglobigerina* ex gr. *E. fringa, Parasubbotina pseudobulloides*, *Praemurica* ex gr. *P. inconstans,* and *P.* ex gr. *P. uncinata* (Text-figure 11B).

In spot samples in the Haymana section (Text-figures 2, 4), the author examined samples W1 to W4, N1, Y2, Y1, N2 and S1,

| | Species / Sampling station | 101 | 102 | 103 | 104 | 202 | 201 | 203 | 204 | 302 | 303 | 401 | 403 | 405 | 504 | 505 | 601 | 602 | 603 | 604 | 605 | 606 | 607 | 608 | 701 | 702 | 801 | 802 | 803 | 804 | 805 | 806 | 807 | 808 | 809 | 810 | 901 | 902 | 903 | 904 | 905 | 906 | 907 | 908 | 909 | 910 | 911 | 912 | 913 | 914 | 915 | 916 | 917 | 920 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Anomalinoides rubiginosus | | | | X | X | | X | X | X | | X | X | | X | | X | | | X | X | | | | | | | | | X | X | | | X | X | X | X | | X | X | | | | X | X | X | | | | | X | | | X |
| 2 | Asterocyclina stella | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | A. spp. | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | Clypeorbis mammillatus | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 5 | Conorbitoides cristalensis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | X | | X | | | | X | | |
| 6 | Cuvillierina soezerii | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | | X | X | X | | X | | X | X | X | | | X | | X | X | | X |
| 7 | C. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | |
| 8 | Daviesina danieli | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | |
| 9 | D. langhami | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | Dictyokathina simplex | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | Discocyclina seunesi | | | | X | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | D. spp. | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | Hellenocyclina beotica | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | X | X | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | Helicorbitoides voigti | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | H. longispiralis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | |
| 16 | Kathina selveri | | | | | | | | X | | X | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 17 | K. spp. | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | Laffitteina bibensis | | | | | | | | | | | | | X | | X | | | | | X | X | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | Lepidorbitoides minor | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | X | | | X | | |
| 20 | L. socialis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | |
| 21 | L. spp. | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | X | | | | X | X | | | X | | X | | | |
| 22 | Miscellanea globularis | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 23 | M. primitiva | | | | | | | | X | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24 | Mississippina binkhorsti | | | | | | | | X | | | | | X | | | | | | | | | | X | | | | | | | | | | X | X | | | | | | | | | X | X | X | | | | | | | | |
| 25 | Omphalocyclus macroporus | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | X | | | | | | | | | | | X | | X | | X | | | X | | X | X | | |
| 26 | Orbitoclypeus ramaraoi | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27 | Orbitoides apiculata | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | X | | | | X | | X | | | |
| 28 | O. gruenbachensis | | | | | | | | X | | | | | | | | | | | | | | | | | | | | X | X | X | X | | | | | | X | X | | | | | | | | | | | | X | | | |
| 29 | O. media | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | X | | | | | | | X | X | | X | X | X | | | | | | | | X | | | |
| 30 | O. megaloformis | | | | | | | | X | | | | | | | | | | | | | | | | | | | | X | X | | X | | | | | | X | | | X | | | | | | | | | | | | | |
| 31 | O. tissoti | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | X | X | | X | | | X | X | | | | | | | X | | |
| 32 | O. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | |
| 33 | Planorbulina cretae | | | | X | | | | | | | | X | | | | | | X | | X | | | | | | | | | X | | | | | | | | | | X | | | | | | | | | | | X | | | X |
| 34 | Pseudorbitoides trechmanni | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | X | X | | | | | X | X | | | | | | | | | |
| 35 | Pseudosiderolites vidali | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | X | | | | | |
| 36 | Ranikothalia nuttalli | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 37 | Rotalia trochidiformis | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | |
| 38 | R. spp. | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | X | | X | X | | | X | | X | | | X | | X | | | X |
| 39 | Siderolites calcitrapoides | | | | | | | | X | | | | | | | | | | | | | | | | | | X | X | X | X | | | | | | | | X | X | | X | | | | | | | | X | | X | X | | X |
| 40 | Simplorbites papyraceus | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | X | X | | X | X | X | X | X | | | | | | X | X | | |
| 41 | Sirtina orbitoidiformis | | | | X | | | | | | | | | | | | | | | | | | | | | | X | | | | X | | | | | | X | X | | X | X | | | X | X | X | X | | X | | X | | | X |
| 42 | Sistanites iranica | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 43 | Sivasella monolateralis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 44 | Sulcoperculina dickersoni | | | | | | | | | | | | | | | | | | | | | | | | | | X | | X | X | X | X | | | | | | X | X | X | X | X | X | X | X | X | | | | | X | | | X |
| 45 | Sulcorbitoides pardoi | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | | X | | | |
| 46 | Broeckinella arabica | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | |
| 47 | Chrysalidina spp. | | | | | | | | | X | | | | | | X | | | | X | | | | | | | | | X | X | | | X | X | | | | | | X | | | X | | | X | | | | | | | | |
| 48 | Coskinon rajkae | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 49 | Loftusia spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | |
| 50 | Minouxia spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 51 | Navarella joaguini | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | X | X | | | |
| 52 | Pseudochrysalidina spp. | | | X | | | | | X | | | | | | | | | | | | | | | | | | | | X | X | | | | X | | | | | | | | | | | | | | | | | | | | |
| 53 | Pseudolituonella spp. | | | | X | | | | | X | | | | | X | | | | | | | | | | | | | | | | X | | | | | | | | | | | | X | | | | | | | | | | | |
| 54 | Textularia spp. | | | | | | | | | | | X | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 55 | Valvulina spp. | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | |
| 56 | Hoeglundina elegans | | | | X | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | X | | | | | X | | | |
| 57 | Idalina sinjarica | | | | | | | | X | X | | | | X | | | | X | X | | X | | X | X | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 58 | Keramosphaerina spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 59 | Lenticulina spp. | | | | X | | | | | | | | | | | | X | X | | | | | | | | | | | X | X | | X | | | | X | | | | | | | | X | | | | | | | X | | | |
| 60 | Opthalmidium spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | X | | | | | | | | | | | | | | | | | | | | |
| 61 | Dentalina spp. | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | X | | | | X | | X | | | | | | | | | | | | | | | | | | |
| 62 | Scandonea samnitica | | | | | | | | | | | | | X | X | | | | X | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

TEXT-FIGURE 10A

Distribution chart of larger benthic foraminifera from the upper Cretaceous (K) Kakarca, Taraklı and Seben Formations, Paleocene (T) Yağhane, Salvipinari and Halidiye Formations and upper Cretaceous-Paleocene transitional Akveren and Hisalköy Formations in the Black Sea region (Text-figures 1, 7).

which were collected by Dr. Kemal Erdoğan, M.T.A., Turkey, from the same sampling stations by Özcan and Özcan Altiner (1991, fig. 1) (Text-figures 2, 4). The lower Haymana Formation (samples W1, W2, W3 and W4) yields *Lepidorbitoides bisambergensis* (Jaeger), *L. campaniensis* Van Gorsel, *L. pembergeri* Papp, *L. socialis, L.* spp., *Orbitoides gruenbachensis, O. media, O. megaloformis, O. tissoti, Planorbulina cretae, Pseudorbitoides trechimanni* Douvillé, *Pseudosidero-*

| No. | Species \ Sampling station | 921 | 922 | 923 | 924 | 925 | 926 | 927 | 928 | 929 | 930 | 931 | 932 | 933 | 934 | 935 | 936 | 937 | 938 | 939 | 921915 | 1001 | 1002 | 1003 | 1004 | 1005 | 1006 | 1007 | 1008 | 1009 | 1010 | 1011 | 1012 | 1013 | 1014 | 1015 | 1016 | 1220 | 1221 | 1222 | 1225 | 1226 | 1227 | 1228 | 1229 | 1230 | 1233 | 1235 | 1301 | 1302 | 1303 | 1304 | 734 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Anomalinoides rubiginosus | X | X | X | | | | | X | | | X | X | | | X | | | X | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | |
| 2 | Asterocyclina stella | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | A. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | Clypeorbis mammillatus | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | Conorbitoides cristalensis | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | Cuvillierina soezerii | | X | X | X | X | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | C. spp. | | X | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | Daviesina danieli | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | X | | | | | | | | | | | | | | | | | | | | |
| 9 | D. langhami | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | |
| 10 | Dictyokathina simplex | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | Discocyclina seunesi | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | D. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | Hellenocyclina beotica | X | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | Helicorbitoides voigti | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X |
| 15 | H. longispiralis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X |
| 16 | Kathina selveri | | | | | | | | | | | | | | | | | | X | X | X | | | | | | | | | | | | | | | | | | | | | | | | | X | | X | | | | | |
| 17 | K. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | Laffitteina bibensis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | Lepidorbitoides minor | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | L. socialis | | | | | | X | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 21 | L. spp. | | | X | X | X | X | X | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 | Miscellanea globularis | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | |
| 23 | M. primitiva | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 24 | Mississippina binkhorsti | X | | | | | | | X | | X | | | | | X | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25 | Omphalocyclus macroporus | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 26 | Orbitoclypeus ramaraoi | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27 | Orbitoides apiculata | | | | X | X | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28 | O. gruenbachensis | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 29 | O. media | | | | X | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X |
| 30 | O. megaloformis | | | X | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 31 | O. tissoti | | | X | | | | X | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X |
| 32 | O. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 33 | Planorbulina cretae | X | X | | | | | | | | X | X | | | | X | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | |
| 34 | Pseudorbitoides trechmanni | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 35 | Pseudosiderolites vidali | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X |
| 36 | Ranikothalia nuttalli | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 37 | Rotalia trochidiformis | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | X | | | | | | | | | | | | | | | | | | | | | | |
| 38 | R. spp. | | X | X | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | |
| 39 | Siderolites calcitrapoides | X | | X | X | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 40 | Simplorbites papyraceus | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 41 | Sirtina orbitoidiformis | X | X | X | X | X | X | X | X | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | X | | | | | |
| 42 | Sistanites iranica | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | X | | | | | | |
| 43 | Sivasella monolateralis | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 44 | Sulcoperculina dickersoni | X | | X | | X | X | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 45 | Sulcorbitoides pardoi | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 46 | Broeckinella arabica | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 47 | Chrysalidina spp. | | | | | | | | | | X | X | | | | | | | | X | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | |
| 48 | Coskinon rajkae | | | | | | | | | | | | | | | | | | | | X | | | | | | | | X | X | X | | X | | | | | | | | | | | | | | | | | | | | |
| 49 | Loftusia spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 50 | Minouxia spp. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | |
| 51 | Navarella joaguini | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | X | | | | | | | | | | X | | | |
| 52 | Pseudochrysalidina spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | |
| 53 | Pseudolituonella spp. | X | | | | | | | | | X | | | X | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | |
| 54 | Textularia spp. | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | X | | | | | | |
| 55 | Valvulina spp. | | | | | | | | | | | X | | | | | | | X | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 56 | Hoeglundina elegans | | | | | | | | X | | X | | | | | X | | | X | X | X | | | | X | | | | | | | | | | | | | | | | | | | | | X | X | X | | | | | |
| 57 | Idalina sinjarica | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | X | | | | X | | | | | | | | | | | | | | | | | | | | |
| 58 | Keramosphaerina spp. | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 59 | Lenticulina spp. | | | | | | | | | | X | | | | | | | | X | | | | | | | | | | | | | | X | | | | | | | | | | | X | | | | | | | | | |
| 60 | Opthalmidium spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 61 | Dentalina spp. | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 62 | Scandonea samnitica | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

TEXT-FIGURE 10B
Distribution chart of larger benthic foraminifera from the upper Cretaceous-Paleocene transitional Hisarköy and Akveren Formations and upper Cretaceous Buldandere Formation of sample locality 734, Bolu (Sirel 1995) in the Black Sea region (Text-figures 1, 7).

lites vidali, Simplorbites *papyraceus, Sirtina orbitoidiformis, Sivasella monolateralis, Sulcoperculina dickersoni*, *Minouxia* spp., *Pseudolituonella* spp., *Textularia* spp. and *Pseudedomia hamaouii* (Text-figure 5B). The present fauna is assigned to the Assemblage 1 due to occurrences of *Lepidorbitoides campaniensis, L. bisambergensis, Orbitoides tissoti, O. media, O. megaloformis, O. gruenbachensis, Planorbulina cretae* and *Pseudosiderolites vidali* (Text-figure 13). The Assemblage 1 is

| | Species / Sampling stati | 101 | 102 | 103 | 104 | 202 | 201 | 203 | 204 | 302 | 303 | 401 | 403 | 405 | 504 | 505 | 601 | 602 | 603 | 604 | 605 | 606 | 607 | 608 | 701 | 702 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Globoconusa ex gr.G.daubjergensis | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | Parvularugoglobigerina ex gr. P.eugubina | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | Eoglobigerina ex gr.E. fringa | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | Subbotina triloculinoides | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | S. spp. | X | | | | | | | X | | | | | | | | | X | X | X | | | | | | |
| 6 | Parasubbotina pseudobulloides | | | | | | | | | | | | | | | | | | | X | | | | | | |
| 7 | P. trinidadensis | | | | | | | | | | | | | | | | | | | X | | | | | | |
| 8 | Praemurica ex gr.P.inconstans | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | P. ex gr. P. uncinata | X | | | | | | | | | | | | | | | | X | X | X | | | | | | |
| # | Morozovella velascoensis | X | | | | | | | | | | | | | | | | | | | | | | | | |
| # | M. aequa | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | M. spp. | | | | | | | | X | | | | | | | | | X | X | X | | | | | | |
| # | Acarinina mckannai | X | | | | | | | | | | | | | | | | | | | | | | | | |
| # | A. spp. | | | | | | | | X | | | | | | | | | | | | | | | | | |
| # | Globanomalina chapmani | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | G. compressa | | | | | | | | X | | | | | | | | | | | | | | | | | |
| # | G. pentagonalis | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | G. pseudomenardii | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | G. spp. | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | Igorina pusilla | X | X | | | | | | | | | | | | | | | | | | | | | | | |
| # | Globigerinelloides spp. | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | Heterohelix spp. | | | | | | X | | | | | | | | | | | | | | | | | | | |
| # | Guembelitria cretacea | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | Contusotruncana contusa | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | C. fornicata | | | | | | X | | | | | | | | | | | | | | | | | | | |
| # | Globotruncana aegyptiaca | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | G. arca | | | | | | X | | | | | | | | | | | | | | | | | | | |
| # | G. esnehensis | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | G. falsostuarti | | | | | | X | | | | | | | | | | | | | | | | | | | |
| # | G. linneiana | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | G. spp. | | | | | | X | | | | | | | | | | | | | | | | | | | |
| # | Globotruncanita conica | | | | | | X | | | | | | | | | | | | | | | | | | | |
| # | G. stuarti | | | | | | X | | X | | | | | | | | | | | | | | | | | |
| # | G. stuartiformis | | | | | | X | | | | | | | | | | | | | | | | | | | |
| # | G. spp. | | | | | | X | | | | | | | | | | | | | | | | | | | |
| # | Globotruncanella citae | | | | | | X | | X | | | | | | | | | | | | | | | | | |
| # | G. petaloidea | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | G. spp. | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | Abathomphalus mayaroensis | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | A. intermedius | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | Rugoglobigerina macrocephala | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | R. rugosa | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | R. scotti | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | R. spp. | | | | | | X | | X | | | | | | | | | | | | | | | | | |
| # | Gansserina gansseri | | | | | | X | | X | | | | | | | | | | | | | | | | | |
| # | Pseudotextularia elegans | | | | | | X | | | | | | | | | | | | | | | | | | | |
| # | Racemiguembelina fructicosa | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | Rugotruncana subpenny | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | R. spp. | | | | | | | | | | | | | | | | | | | | | | | | | |

| | Species / Sampling stati | 801 | 802 | 803 | 804 | 805 | 806 | 807 | 808 | 809 | 810 | 901 | 902 | 903 | 904 | 905 | 906 | 907 | 908 | 909 | 910 | 911 | 912 | 913 | 914 | 915 | 916 | 917 | 920 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Globoconusa ex gr.G.daubjergensis | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | Parvularugoglobigerina ex gr. P.eugubina | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | Eoglobigerina ex gr.E. fringa | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | Subbotina triloculinoides | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | S. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | Parasubbotina pseudobulloides | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | P. trinidadensis | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | Praemurica ex gr.P.inconstans | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | P. ex gr. P. uncinata | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | Morozovella velascoensis | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | M. aequa | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | M. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | Acarinina mckannai | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | A. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | Globanomalina chapmani | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | G. compressa | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | G. pentagonalis | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | G. pseudomenardii | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | G. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | Igorina pusilla | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | Globigerinelloides spp. | | | | | | | | | | | | | X | | | | | | | | | | | | | | | |
| # | Heterohelix spp. | | | | | X | | | | | | X | | | | | | | | | X | | | | | | | | |
| # | Guembelitria cretacea | | | | | | | | | | | | | | | | | | X | | | | | | | | | | |
| # | Contusotruncana contusa | | | | | | | | | | | | X | X | X | | X | | X | X | X | | | | X | | | | X |
| # | C. fornicata | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | |
| # | Globotruncana aegyptiaca | | | | | | | | | | | | | | | | | X | | X | X | | | | X | | | | |
| # | G. arca | | | | | | | | | | | | | X | | | X | X | | | | | | | | | | | |
| # | G. esnehensis | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | G. falsostuarti | | | | | | | | | | | X | X | X | | | | | X | | | | | | | | | | |
| # | G. linneiana | | | | | | | | | | | | | | | | X | X | X | | | | | | | | | | X |
| # | G. spp. | | | | | | | | | | | X | X | X | | | X | | X | | X | | | | | | | | |
| # | Globotruncanita conica | | | | | | | | | | | | | X | | | X | | X | | | | | | X | | | | |
| # | G. stuarti | | | | | | | | | | | | | X | | | | X | | | X | | | | X | | | | X |
| # | G. stuartiformis | | | | | | | | | | | | | X | | | | | X | | | | | | | | | | X |
| # | G. spp. | | | | | | | | | | | | | | X | | | | | | | | | | | | | | |
| # | Globotruncanella citae | | | | | | | | | | | | | | | | | | | | | | | | X | | | | |
| # | G. petaloidea | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | G. spp. | | | | | | | | | | | | | | | | | X | | | | | | | | | | | |
| # | Abathomphalus mayaroensis | | | | | | | | | | | | | | | | | | X | | | | | X | X | | | | X |
| # | A. intermedius | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | Rugoglobigerina macrocephala | | | | | | | | | | | | | | | | | | | | | | | | X | | | | |
| # | R. rugosa | | | | | | | | | | | | | X | | | | | | | | | | | | | | | |
| # | R. scotti | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | R. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | X | |
| # | Gansserina gansseri | | | | | | | | | | | | | X | | | | | | | | | | | | | | | |
| # | Pseudotextularia elegans | | | | | | | | | | | | | | | | | X | | | | | | | | | | | |
| # | Racemiguembelina fructicosa | | | | | | | | | | | | | | | | | | X | | | | | | | | | | |
| # | Rugotruncana subpenny | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | R. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

TEXT-FIGURE 11A
Distribution chart of planktonic foraminifera from the same formations (Text-figure 10 A) in the Black Sea region.

correlated with the late Campanian fauna of CVIa to CVIII benthonic foraminiferal zones of Charentes and Dordogne, France, due to common occurrences of *Orbitoides tissoti, Lepidorbitoides campaniensis, L. bisambergensis, Siderolites* (= *Pseudisiderolites*) *vidali* and *Planorbulina cretae* (Bignot and Neumann 1991, tables 2-3). *Lepidorbitoides pembergeri, Pseudorbitoides trechimanni* and *Sulcoperculina dickersoni* in the Assemblage 1 have not yet been known in France. Also, sample W1 yields the planktonic foraminifera *Globotruncanita stuartiformis*, but nothing else is occurred (Text-figure 6B). Özcan and Özcan Altiner (1997, 1999) announced the Unit C (samples HAY-W-82, HAY-W-91 and HAY-W-95) of the Haymana Formation (Text-figure 4) to be *Radotruncana calcarata* planktic foraminiferal zone of the upper Campanian, which is equivalent to Sliter's Zone KS27 (Sliter 1989). The author couldn't, however, find *Globotruncanita calcarata* (Cushman), except *Globotruncanita elevata* and *G.* cf. *subspinosa* (Text-figures 6A, 6B). Toker (1980) described the planktonic foraminifera such as *Globotruncanita elevata*, *G. stuarti, Globotruncana lapparenti* Bolli, *G. ventricosa* White and *G. tricarinata* (Quereau) from the lower Haymana Formation, and regarded to be the Campanian age, but she couldn't find *G. calcarata*. The present Assemblage 1 in this study is tentatively regarded as the Zone KS27 of planktonic foraminiferal zones (Sliter 1989), which is correlated with the late Campanian age. Sample N1 from the Unit C yields *Anomalinoides rubinosus, Mississippina binkhorsti, Orbitoides media, Pseudolituonella* spp. and *Textularia* spp. (Text-figure 5B), in association with the planktonic foraminifera *Heterohelix* spp. and *Globotruncanita stuartiformis* (Text-figure 6B). The present assemblage is assigned to the Assemblage 2, and don't yield *Orbitoides apiculata* and *Lepidorbitoides socialis*, which indi-

| No. | Species / Sampling station | 921 | 922 | 923 | 924 | 925 | 926 | 927 | 928 | 929 | 930 | 931 | 932 | 933 | 934 | 935 | 936 | 937 | 938 | 939 | 921015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Globoconusa ex gr. G.daubjergensis | | | | | | | | | | ? | | ? | ? | | | | | | | X |
| 2 | Parvulargoglobigerina ex gr. P.eugubina | | | | | | | | | | X | | X | X | | | | | | | |
| 3 | Eoglobigerina ex gr. E. fringa | | | | | | | | | | ? | | ? | X | | | | | | | |
| 4 | Subbotina triloculinoides | | | | | | | | | | | | | | | | X | | X | | X |
| 5 | S. spp. | | | | | | | | | | | | X | X | | X | | | X | | X |
| 6 | Parasubbotina pseudobulloides | | | | | | | | | | | | X | X | | X | | | X | | X |
| 7 | P. trinidadensis | | | | | | | | | | | | | | | X | X | | | | X |
| 8 | Praemurica ex gr. P.inconstans | | | | | | | | | | | | | | | | | | | | |
| 9 | P. ex gr. P. uncinata | | | | | | | | | | | | | | | | | | | | |
| 10 | Morozovella velascoensis | | | | | | | | | | | | | | | | | | X | | |
| 11 | M. aequa | | | | | | | | | | | | | | | | | | X | | |
| 12 | M. spp. | | | | | | | | | | | | X | | | X | X | | | X | |
| 13 | Acarinina mckannai | | | | | | | | | | | | | | | | | | | | |
| 14 | A. spp. | | | | | | | | | | | | | | | | | | X | X | |
| 15 | Globanomalina chapmani | | | | | | | | | | | | | | | | X | | X | | |
| 16 | G. compressa | | | | | | | | | | | | | | | | X | | | | |
| 17 | G. pentagonalis | | | | | | | | | | | | | | | | | | | | |
| 18 | G. pseudomenardii | | | | | | | | | | | | | | | | | | | X | |
| 19 | G. spp. | | | | | | | | | | | | | | | | | | X | | |
| 20 | Igorina pusilla | | | | | | | | | | | | | | | | | | | | X |
| 21 | Globigerinelloides spp. | | | | | | | | | | X | | | | | | | | | | |
| 22 | Heterohelix spp. | X | | | | | | X | X | | X | | | X | | | | | | | X |
| 23 | Guembelitria cretacea | | | | | | | | | | | | | | | | | | | | |
| 24 | Contusotruncana contusa | X | | | | | X | | X | | X | | | | | | | | | | |
| 25 | C. fornicata | | | | | | | | X | | | | | | | | | | | | |
| 26 | Globotruncana aegyptiaca | X | | | | | | | | | | | | | | | | | | | |
| 27 | G. arca | X | | | | | | | | | | | | | | | | | | | |
| 28 | G. esnehensis | | | | | | | | X | | | | | | | | | | | | |
| 29 | G. falsostuarti | X | | | | | | | X | | X | | | X | | | | | | | |
| 30 | G. linneiana | | | | | | | | | | X | | | | | | | | | | |
| 31 | G. spp. | | | | | | | | X | | X | | | | | | | | | | |
| 32 | Globotruncanita conica | | | | | | | | | | | | | | | | | | | | |
| 33 | G. stuarti | X | | | | | | | X | | X | | | | | | | | | | |
| 34 | G. stuartiformis | | | | | | | | | | | | | | | | | | | | |
| 35 | G. spp. | | | | | | | | | | | | | | | | | | | | |
| 36 | Globotruncanella citae | | | | | | | | | | | | | | | | | | | | |
| 37 | G. petaloidea | | | | | | | | | | | | | | | | | | | | |
| 38 | G. spp. | | | | | | | | | | | | | | | | | | | | |
| 39 | Abathomphalus mayaroensis | | | | | | | | X | | X | | | | | | | | | | X |
| 40 | A. intermedius | | | | | | | | | | | | | | | | | | | | |
| 41 | Rugoglobigerina macrocephala | | | | | | | | | | | | | | | | | | | | |
| 42 | R. rugosa | | | | | | | | | | X | X | | | | | | | | | |
| 43 | R. scotti | | | | | | | | | | | | | | | | | | | | |
| 44 | R. spp. | | | | | | | X | | | X | | | | | | | | | | |
| 45 | Gansserina gansseri | | | | | | | | | | | | | | | | | | | | |
| 46 | Pseudotextularia elegans | | | | | | | | X | | | | | | | | | | | | |
| 47 | Racemiguembelina fructicosa | | | | | | | | X | | | | | | | | | | | | |
| 48 | Rugotruncana subpenny | | | | | | | | | | | | | | | | | | | | |
| 49 | R. spp. | | | | | | | | | | | | | | | | | | | | |

| No. | Species / Sampling station | 1001 | 1002 | 1003 | 1004 | 1005 | 1006 | 1007 | 1008 | 1009 | 1010 | 1011 | 1012 | 1013 | 1014 | 1015 | 1016 | 1220 | 1221 | 1222 | 1225 | 1226 | 1227 | 1228 | 1229 | 1230 | 1233 | 1235 | 1301 | 1302 | 1303 | 1304 | 734 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Globoconusa ex gr. G.daubjergensis | | | | | | | | | | | | | X | X | X | | | | | | | | | X | | | | | | | | |
| 2 | Parvulargoglobigerina ex gr. P.eugubina | | | | | | X | | | | | | | | X | | | | | | | | | X | X | | | | | | | | |
| 3 | Eoglobigerina ex gr. E. fringa | | | | | | X | | | | | | | | | | | | | | | | | X | | | | | | | | | |
| 4 | Subbotina triloculinoides | | | | | | X | | | | | X | | | | X | | | | | | | | | X | | | X | | | | | |
| 5 | S. spp. | | | | | | | | X | | X | X | | | X | X | X | | | | | | | X | X | | X | | | | X | X | |
| 6 | Parasubbotina pseudobulloides | | | | | | X | | X | | | | | X | | | | | | | | | | X | X | X | | X | | | | | |
| 7 | P. trinidadensis | | | | | | X | | X | X | X | X | | | | | | | | | | | | | X | X | X | | | | | | |
| 8 | Praemurica ex gr. P.inconstans | | | | | | X | | | | | | | | | | | | | | | | | X | X | | | | | | | | |
| 9 | P. ex gr. P. uncinata | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | |
| 10 | Morozovella velascoensis | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | |
| 11 | M. aequa | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | |
| 12 | M. spp. | | | | | | | X | X | | X | | | X | | X | X | | | | | | | X | | | | | | | | X | |
| 13 | Acarinina mckannai | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | |
| 14 | A. spp. | | | | | | | | | | | | X | | | X | X | | | | | | | | | | | | | | | | |
| 15 | Globanomalina chapmani | | | | | | | | | | | X | | | | | X | | | | | | | | | | | | | | | | |
| 16 | G. compressa | | | | | | X | | | X | | | | X | | | | | | | | | | | X | | | | | | X | | |
| 17 | G. pentagonalis | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | G. pseudomenardii | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | |
| 19 | G. spp. | | | | | | X | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 20 | Igorina pusilla | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | |
| 21 | Globigerinelloides spp. | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 | Heterohelix spp. | X | X | | X | X | | | | | | | | | | | | | | | | | | | X | | X | X | | | | | |
| 23 | Guembelitria cretacea | | | X | | X | | | X | | | | | | | | | | | | | | | | | | | X | | | | | |
| 24 | Contusotruncana contusa | X | | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | |
| 25 | C. fornicata | X | X | | | | | | | | | | X | | | | | | X | X | X | X | | | | | | | | | | | |
| 26 | Globotruncana aegyptiaca | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 27 | G. arca | X | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 28 | G. esnehensis | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | |
| 29 | G. falsostuarti | | | X | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | |
| 30 | G. linneiana | X | X | | | | | | | | | | X | | | | | X | | | | | | | X | X | | | | | | | |
| 31 | G. spp. | X | | | X | X | X | X | | X | | X | X | X | | | | | | | X | | | X | X | | | | X | X | | | |
| 32 | Globotruncanita conica | | | | | | | | | | | | | | | | | | | X | X | | | | | | X | | | | | | |
| 33 | G. stuarti | X | | X | X | | | | | | | | X | | | | | X | | | | | X | X | | | | | | | | | |
| 34 | G. stuartiformis | X | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | X |
| 35 | G. spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 36 | Globotruncanella citae | | | X | X | | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 37 | G. petaloidea | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 38 | G. spp. | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 39 | Abathomphalus mayaroensis | | | X | X | | | | | | | | X | X | X | | | X | | | | | | | | | | | | | | | |
| 40 | A. intermedius | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 41 | Rugoglobigerina macrocephala | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 42 | R. rugosa | X | | X | X | X | | | | | | | X | | | | | | X | | | | | | | | | | | | | | |
| 43 | R. scotti | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 44 | R. spp. | X | X | X | X | | X | | | | | | | X | X | | | X | | X | | | | | X | | X | | | | | | |
| 45 | Gansserina gansseri | X | | | | | | | | | | | | | | | | X | X | | X | | | | | | | X | | | | | |
| 46 | Pseudotextularia elegans | X | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 47 | Racemiguembelina fructicosa | X | | X | | X | | | | | | | | | X | | | | | | | | | | | | | | | | | | |
| 48 | Rugotruncana subpenny | X | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 49 | R. spp. | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

TEXT-FIGURE 11B
Distribution chart of planktonic foraminifera from the same formations (Text-figure 10B) in the Black Sea region.

cate the Assemblage 3. The Assemblage 2 is tentatively regarded as the Zones KS28? to KS30 (Text-figure 13). Rock samples Y2, Y1, N2 and S1 from the Haymana or Beyobasi Formations yield *Amomalinoides rubiginosus, Lepidorbitoides* spp., *Mississippina binkhorsti, Omphalocyclus macroporus, Orbitoides media, Planorbulinella cretae, Siderolites calcitrapoides, Sivasella monolateralis, Chrysalidina* spp., *Textularia* spp., *Opthalmidium* spp. and *Scandonea samnitica* (Text-figure 5B). Further, samples Y1 and S1 yield the planktonic foraminifera *Hedbergella* spp. and *Abathomphalus mayaroensis* (Bolli) (Text-figure 6B). The present assemblage is poor occurrences due to the low diversity of species, but may be regarded as the Assemblage 3 or Assemblage 4, because Assemblages 3 and 4 are characterized by common occurrences of *Orbitoides apiculata, Lepidorbitoides socialis* and *Omphalocyclus macroporus* together with *Abathomphalus mayaroensis* of the Zone KS31 (Sliter 1989). This zone is known from the Hisalköy Formation in the Cide section (section 9), the Black Sea region as stated later.

**The Black Sea region**

The total 12 columnar sections in sampling localities in the Black sea region except Sabirli, Alapli (section 11) are treated to examine the upper Cretaceous to Paleocene sedimentary rocks of the Sakarya-Pontid Platform, main tectonic units of Turkey (Matsumaru et al. 1996, 1997; Text-figures 1, 7). The Maastrichtian Kakarca Formation in the western Pontid zone is composed of gray colored sandy limestone and dark gray colored claystone, which is laterally graded into the Taraklı Formation, composed of yellow colored sandstone (Matsumaru et al. 2010, text-fig. 1; Text-figure 7). Both formations are overlain by the Paleocene Yağhane Formation (composed of gray colored marl, limestone, alternation of marl and limestone, and limestone) and Salvipinari Formation (composed of yellow colored limestone and sandstone) in Tavşantepe, Gebze (section 1) through Kizderbent, Karamursel (section 2), Yaðhane, Iznik (section 3) and Güneytepe, Iznic (section 4) to Medetlı, Gölpazarı (section 5) localities (Bargu and Sakinc 1987, 1989; Dizer and Meriç 1983; Meriç and Sengüler 1986; Altinlı 1973; Text-figure 7). The Maastrichtian Seben Formation in Kayabogazi, Göynuk (section 6) is composed of gray colored limestone and alternation of yellowish brown colored sandstone and gray colored marl, and is overlain by the Paleocene Halidiye Formation (composed of alternation of gray colored limestone and yellowish brown colored sandstone, limestone and yellowish brown colored sandstone and limestone) (Meriç and Şengüler 1986; Text-figure 7). The Maastrichtian to Danian-Thanetian Hisarköy Formation (composed of alternation of light gray colored limestone and green and dark red colored shale) and Thanetian-Ilerdian? Akgüney Formation (composed of thinly bedded clayey limestone) has developed widely in Cide (section 9) (Akyol et al. 1974; Sirel 1973, 1991; Özcan and Özkan Altiner 1999; Text-figure 7). The Maastrichtian-Paleocene (Thanetian) Akveren Formation (composed of a sequence of interbeded light gray colored limestone and marl, and minor lava flows, tuffs and sandstone) has developed in Siyamoğlu, Mengen (section 7), Devrekani, Kastamonu (section 8), Kokaksu, Zongludak (section 10), Avdal, Ağva (section 12) and Yeşilçay, Ağva (section 13) (Ketin and Görmüs 1963; Kaya et al. 1984; Tansel 1989; Text-figure 7).

**1. Tavşantepe Section, Gebze** (Text-figures 1, 7). The Yağhane Formation (samples 101 to 104) yields *Anomalinoides rubiginosus, Discocyclina seunesi, Kathina* spp., *Planorbulina cretae,* **Sirtina orbitoidiformis, Pseudochrysalidina* spp., *Pseudolituonella* spp., *Valculina* spp., *Hoeglundina elegans* (d'Orbigny), and *Lenticulina* spp. (Text-figure 10A). Asterisk species is reworked. The present fauna is assigned to the Assemblage 8 due to common occurrences of *Anomalinoides rubiginosus, Discocyclina seunesi* and *Kathina* spp. (Text-figure 13). Also samples 101 and 102 yield the planktonic foraminifera, *Subbotina* spp., *Praemurica* ex gr. *P. uncinata, Morozovella velascoensis* (Cushman), *Acarinina mckannai* (White) and *Igorina pusilla* (Text-figure 11A), and these species indicate the Zone P4 (Blow 1969; Berggren and Van Couvering 1974; Toumarkine and Luterbacher 1985; Berggren et al. 1995). Further, the present assemblage is partial correlated to the Assemblage 8 in the Ilginlikdere Formation (sample 921013-1) in the Polatli (Kirkavak) section, Ilginlikdere Formation (samples KM24 to KM17) in the Çaldağ section, and Yesilyurt Formation (samples KM19 to KM13) in the Çayraz section, all of the Haymana region, due to occurrences of *Anomalinoides rubiginosus, Discocyclina seunesi*; *Valvulina* spp., and *Kathina* spp.

**2. Kizderbent Section, Yalakdere, Karamursel** (Text-figures 1, 7). The Kakarca Formation (samples 202 and 203) yields *Anomalinoides rubiginosus*, which is very poor in the low diversity, and the faunal zone is obscure (Text-figure 10A). It may be the Assemblage 2 or 3. Sample 201 yields the planktonic foraminifera *Heterohelix* spp., *Contusotruncana fornicata*, *Globotruncana arca* (Cushman), *G. falsostuarti, G.* spp., *Globotruncanita conica* (White), *G. stuarti* (De Lapparent), *G. stuartiormis, G.* spp., *Globotruncanella citae* (Bolli), *Rugoglobigerina* spp., *Gansserina gansseri* (Bolli), and *Pseudotextularia elegans* (Rzehak) (Text-figure 11A). The fauna indicates the Zone KS30 or lower KS31 (Sliter 1989; Caron 1985). The Yaghane Formation (sample 204), which overlies the Kakarca Formation, yields *Anomalinoides rubiginosus, Kathina selveri,* **Lepidorbitoides* spp., *Miscellanea globularis, M. primitiva, Mississippina binkhorsti,* **Orbitoides apiculata,* **O. gruenbachensis,* **O. megaloformis,* **Siderolites calcitrapoides,* **Simplorbites papyraceus Rotalia* spp., *Pseudochrysalidina* spp., and *Idalina sinjarica* (Text-figure 10A). Asterisk six species are reworked. The present assemblage is assigned to the Assemblage 7 due to common occurrences of *Kathina selveri, Miscellanea globularis, M. primitiva* and *Idalina sinjarica* (Text-figure 13). Also, sample 204 yields the planktonic foraminifera, *Subbotina* spp., *Morozovella* spp., *Acarinina* spp., *Globanomalina compressa,* **Globotruncanita stuarti*, **Globotruncanella citae,* **Rugoglobigerina* spp. and **Gansserina gansseri* (Text-figure 11A). Asterisk four species are reworked. These planktonic foraminiferal species indicates the Zone P3 (Blow 1969; Berggren and Van Couvering 1974; Toumarkine and Luterbagher 1985; Berggren et al. 1995). The Yağhane Formation carrying the Assemblage 7 is correlated with the Çaldağ Formation (samples KM2 to KM44) in the Çaldağ section, west Haymana; Çaldağ Formation (samples KM31 to KM36) in the west Haymana section; Çaldağ Formation (samples E1033 to E1031) in the east Erif section; and the Çaldağ Formation (samples KM8 to KM18) in the Bahaçecik section, south Haymana, based on common occurrences of *Anomalinoides rubiginosus, Miscellanea globularis, M. primitiva* and *Idalina sinjarica*.

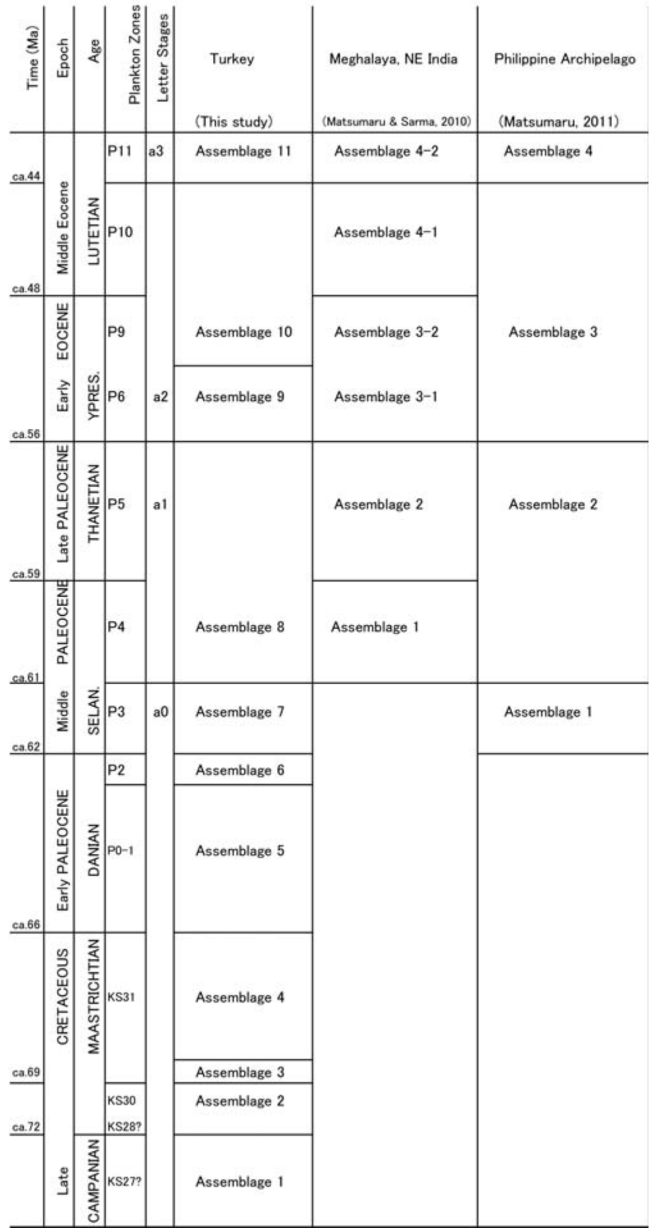
**3. Yağhane Section, Derbent, Iznik** (Text-figures 1, 7). The Yağhane Formation (samples 302 and 303) yields *Anomalinoides rubiginosus, Kathina selveri, Chrysalidina* spp., *Pseudolituonella* spp., and *Idalina sinjarica* (Text-figure 10A). The fauna is very poor due to low diversity, but is assigned to the Assemblage 6 due to common occurrences of *Anomalinoides rubiginosus, Kathina selveri* and *Idalina sinjarica*. The Yağhane Formation, which overlies the upper Cretaceous Taraklı Formation, is widely distributed from Yağhane (section 3) through Güneytepe (section 4) to Medetlı (section 5), and in the Medetlı it is inter-fingering with the Salvipinari Formation. Also, the Salvipinari Formation is correlated with the Halidiye Formation in the Kayabogazi section (section 6) due to *Laffitteina*-bearing beds and similar rock facies (Matsumaru et al. 1996).

**4. Güneytepe Section, Yenisehir, Iznik** (Text-figures 1, 7). The Taraklı Formation (sample 401) yields *Anomalinoides rubiginosus,* and *Textularia* sp. (Text-figure 10A). The fauna is very poor and the assemblage is obscure. The Yağhane Formation (samples 403 and 405) yields *Anomalinoides rubiginosus, Laffitteina bibensis, Mississippina binkhorsti, Planorbulina cretae, Sistanites iranica, Idalina sinjarica* and *Scandonea samnitica* (Text-figure 10A). The present assemblage is assigned to the Assemblage 6 due to common occurrences of *Anomalinoides rubiginosus, Laffitteina bibensis, Planorbulina cretae, Idalina sinjarica* and *Scandonea samnitica*.

**5. Medetlı Section, Gölpazarı** (Text-figures 1, 7-8). The yellow sandstone of the top Taraklı Formation underlying the Paleocene Salvipinari Formation yields the upper Cretaceous (Maastrichtian) bivalve *Exogyra* spp. The basal Salvipinari Formation (sample 504) yields *Anomalinoides rubiginosus, Pseudolituonella* spp. and *Scandonea samnitica* and this fauna is assigned to the Assemblage 5 without *Laffitteina bibensis*

(Text-figures 10A, 13). The Salvipinari Formation (sample 505) yields *Laffitteina bibensis* and *Chrysalidina* spp., *Pseudolituonella* spp. (Text-figure 10A), and this fauna is assigned to the Assemblage 6 due to occurrences of *Laffitteina bibensis.* In a series of author et al.'s research group works, the K-T boundary have been decided into the yellow colored fine grained goethite sandstone (samples 502 and 501) of the topmost Taraklı Formation (Matsumaru et al. 1996, p.24, 1997; Text-figures 7-8). After then, Iridium concentrations for goethite-rich layers (samples 502 (3-02a to 3-02c) and 502´ (3-01)) of the Taraklı Formation were relative low (0.05 - 0.10 ppb), but was slightly elevated (0.24 ppb) in sample MD01 (= sample 501) over the samples 3-10 or 3-18 of the Taraklı Formation (Arakawa et al. 2003, fig. 6, tab. 3; Text-figure 8). As such, the authors concluded that Iridium has been diluted by the sedimentation and diagenesis during the K-T boundary and its successive events. The actual K-T boundary was put on the goethite layers (samples 502 to 501) over the *Exogyra*-bearing sandstone (sample 500) of the Tarakli Formation (Text-figures. 7-8). The authors have analysed major element concentrations for 24 goethite samples in Medetlı, Gölpazarı (Arakawa et al. 2007, table 1). All the 87 Sr/ 86 Sr ratios (0.7077-0.7078) were very close to the measured ratios by DePaolo and Ingram (1985) and Palmer and Elderfield (1985), and it is considered to indicate the condition of the sea water at the K-T boundary time (65-66 Ma). The Ir bearing K-T boundary layers (28-37 cm thick) in the Medetlı sections, Turkey is correlated well with the Ir bearing K-T boundary limonite layers (5 cm thick) in sample W 8 (= J85-26) of the top Mahadeo Formation, Um Sohryngkew River section, Meghalaya, NE India (Bhandari et al. 1987, 1994; Murall et al. 1990; Pandey 1990, fig. 1c). A series of foraminiferal biostratigraphy below and above the K-T boundary is explained in the fauna found from the Hisarköy Formation in the Cide Section (section 9), Turkey. The fauna is correlated with the fauna from the upper Mahadeo Formation in the Um Sohryngkew River section, Meghalaya, NE India (Pandey 1981, 1990; Bhandari et al. 1987, 1994; Murali et al. 1990; Garg and Jain 1995), but not with the uppermost Langpar Formation in the Um Sohryngkew River and Mahadeo sections, Meghalaya (Mukhopadhyay 2008).

**6. Kayabogazi Section, Göynuk** (Text-figures 1, 7). The Halidiye Formation (samples 601 to 606) yields *Anomalinoides rubiginosus, Laffitteina bibensis*, *Planorbulina cretae, Chrysalidina* spp., *Textularia* spp., *Hoeglundina elegans, Idalina sinjarica, Lenticulina* spp., *Dentalina* spp. and *Scandonea samnitica* (Text-figure 10A). The present fauna is assigned to the faunal Assemblage 6, due to common occurrences of *Anomalinoides rubiginosus, Kathina selveri, Laffitteina bibensis, Planorbulina cretae, Idalina sinjarica*, and *Scandonea samnitica* from the lower Yağhane Formation in Yaghane (section 3) to Medetlı (section 5). Also, the Halidiye Formation (samples 602, 603 and 604) yield the planktonic foraminifera, *Subbotina* spp., *Parasubbotina pseudobulloides, P. trinidadensis, Praemurica* ex gr. *P. uncinata,* and *Morozovella* spp. (Text-figure 11A). These planktonic foraminifrea indicate the Zone P2 (Blow 1969; Berggren and Van Couvering 1974; Toumarkine and Luterbacher 1985; Berggren et al. 1995). Samples 607 and 608 yield *Dictyokathina simplex* Smout, *Laffitteina bibensis, Mississippina binkhorsti, Rotalia trochidiformis* and *Idalina sinjarica* (Text-figure 10A), and this fauna is assigned to the Assemblage 8 due to occurrences of *Dictyokathina simplex, Laffitteina bibensis, Rotalia trochidiformis* and *Idalina sinjarica*.

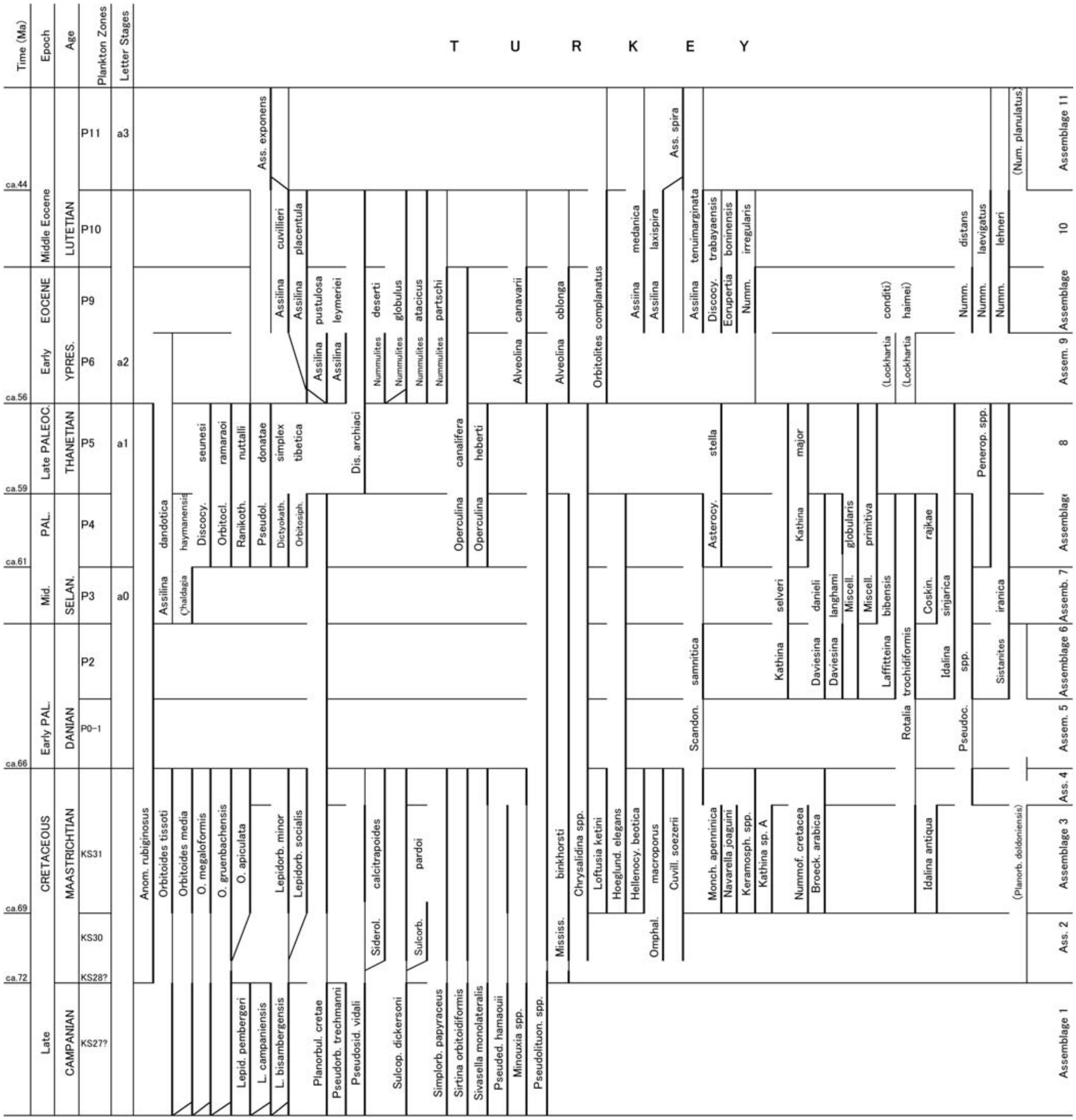



TEXT-FIGURE 12
Correlation chart between the larger benthic foraminiferal assemblages of Turkey in this study; those of Meghalaya, NE India (Matsumaru and Sarma 2010); and those of Philippine Archipelago (Matsumaru 2011); the late Cretaceous to middle Eocene Time scale (official website of ICS (International Commission on Stratigraphy), GTS2012, www.tscreator.org and Berggren et al. 1995; Anthonissen and Ogg 2012); planktonic foraminiferal zones (Sliter 1989; Berggren et al. 1995; Anthonissen and Ogg 2012); and Letter Stages of Philippine Archipelago (Matsumaru 2011; J. Ogg's TSC_InternalDatapack_24-Feb13.xls, p. 6).

**7. Siyamoğlu Section, Mengen** (Text-figures 1, 7). The Akveren Formation (samples 701 and 702) yields *Asterocyclina stella* (Gümbel), *A*. spp., *Discocyclina seunesi*, *D*. spp., *Kathina selveri, Miscellanea primitiva*, *Orbitoclypeus ramaraoi* (Samanta), and *Ranikothalia nuttalli* (Text-figure 10A). The fauna is assigned to the Assemblage 8 due to common occurrences of *Discocyclina seunesi, Orbitoclypeus ramaraoi, Ranikothalia nuttalli, Kathina selveri* and *Miscellanea primitive*. This fauna is correlated with the Assemblage 8 of the Ilginlukdere Formation (sample 921013-1) in the Polatlı (Kirkkavak) section, Ilginlukdere Formation (samples KM24 to KM17) in the Çaldağ section and Yesilyurt Formation (samples KM19 to KM13) in the Çayraz section, Haymana region, and the Yağhane Formation (samples 101 to 104) in Tavşantepe, Gebze (section 1) and Halidiye Formation (samples 607 and 608) in Kayabogazi, Göynuk (section 6), Black Sea region (Text-figures 5A-5B and 11A).

**8. Devrekâni Section, Kastamonu** (Text-figures 1, 7, 9). The Akveren Formation (samples 801 to 806) yields *Anomalinoides rubiginosus, Cuvillierina soezerii, Hellenocyclina beotica, Omphalocyclus macroporus, Orbitoides apiculata, O. gruenbachensis, O. media, O. megaloformis, O. tissoti, Planorbulina cretae, Pseudorbitoides trechimanni, Pseudosiderolites vidali, Rotalia* spp., *Siderolites calcitrapoides, Simplorbites papyraceus, Sirtina orbitoidiformis, Sulcoperculina dickersoni, Chrysalidina* spp., *Loftusia* spp., *Pseudochrysalidina* spp., *Pseudolituonella* spp., *Lenticulina* spp. , *Opthalmidium* spp. and *Dentalina* spp. (Text-figure 10A). The present fauna is assigned to the Assemblage 4, due to common occurrences of *Anomalinoides rubiginosus, Hellenocyclina beotica, Omphalocyclus macroporus*, *Orbitoides apiculatus, Siderolites calcitrapoides, Simplorbites papyraceus,* and *Sirtina orbitoidiformis* from the Beyobasi Formation (samples KM40, KM48 and KM49) in the west Erif section, Haymana region. The Akveren Formation (sample 805) yields the planktonic foraminifera *Heterohelix* spp. (Text-figure 11A). 87Sr/86Sr values of the Akveren Formation (samples 806 and 807) indicate the age nearly 65-66 Ma, and the actual K-T boundary is put on the top of limestone sample 806 of the Akveren Formation (Matsumaru et al. 1996, fig. 3, table 1; Text-figures 7, 9). The upper Akveren Formation (samples 807 to 810) yield *Anomalinoides rubiginosus, Daviesina danieli, Mississippina binkhorsti, Chrysalidina* spp., *Pseudochrysalidina* spp., *Valvulina* spp., *Hoeglundina elegans, Idalina sinjarica*, *Lenticulina* spp., *Opthalmidium* spp., *Dentalina* spp., and *Scandonea samnitica* (Text-figure 10A). This fauna is assigned to the Assemblage 6 due to occurrences of *Daviesina danieli* and *Idalina sinjarica.*

**9. Cide Section** (Text-figures 1, 7). The lower Hisalköy Formation (samples 901 to 907) yields *Anomalinoides rubiginosus, Cuvillierina soezerii, Lepidorbitoides* spp., *Omphalocyclus macroporus, Orbitoides gruenbachensis, O. media*, *O. megaloformis, O. tissoti, O.* spp., *Planorbulina creatae, Pseudorbitoides trechmanni, Rotalia* spp., *Siderolites calcitrapoides, Simplorbites papyraceus, Sirtina orbitoidiformis*, *Sulcoperculina dickersoni, Sulcorbitoides pardoi, Chrysalidina* spp., and *Pseudolituonella* spp. (Text-figure 10A). This fauna is assigned to the Assemblage 2 due to common occurrences of *Orbitoides tissoti, Siderolites calcitrapoides, Sirtina orbitoidiformis, Sulcoperculina dickersoni* and *Sulcorbitoides pardoi*. As such, this fauna is correlated with the faunal Assemblage 2 of the Beyobashi Formation (sample KM9) in the east Erif, Haymana region, and may be correlated with the Kakarca Formation (samples 202 to 203) in Kizderbent (section 2), Black Sea region (Text-gigures 5A, 10A). Also, samples 901 to 907 yields the planktonic foraminifera, *Globigerinelloides* spp., *Heterohelix* spp., *Contusotruncana contusa, Globotruncana aegyptiaca* Nakkady, *G. arca, G. falsostuarti, G. linneiana* (d'Orbigny), *G.* spp., *Globotruncanita conica, G. stuarti, G. stuartiformis, G.* spp., Globotruncanella spp., Rugoglobigerina rugosa, *Gansserina gansseri,* and *Pseudotextularia elegans* (Text-figure 11A). The planktonic foraminiferal fauna indicates the Zone KS30 or *Gansserina gansseri* zone due to occurrences of *G. gansseri* (Sliter 1989; Carlon 1985; Postuma 1971). The lower Hisalköy Formation (samples 908 to 915) yields *Anomalinoides rubiginosus, Clypeorbis mammillatus* Brönnimann, *Conorbitoides cristalensis* Brönnimann, *Cuvillierina soezerii, C.* spp., **Helicorbitoides longispiralis* Papp and Küpper, *Lepidorbitoides minor, L. socialis, L.* spp., *Mississippina binkhorsti, Omphalocyclus macroporus, Orbitoides apiculata, O. gruenbachensis, O. media, O. tissoti, Planorbulina cretae, *Pseudoorbitoides trechimanni, Pseudosiderolites vidali, Rotalia trochidiformis, R.* spp., *Siderolites calcitrapoides, Simplorbites papyraceus, Sirtina orbitoidiformis*, *Sulcoperculina dickersoni, Sulcorbitoides pardoi, Broeckinella arabica* Henson, *Chrysalidina* spp., *Navarella joaguini, Hoeglundina elegans,* and *Lenticulina* spp. (Text-figure 10A). Asterisk two species are reworked from the Campanian beds. The present fauna is assigned to the Assemblage 3 due to common occurrences of *Orbitoides apiculata, Lepidorbitoides socialis* and *Navarella joaguini* (Text-figure 13). As such, this fauna is correlated to the faunal Assemblage 3 of the Beyobasi Formation (samples KM34 to KM41) in the Çaldağ section, west Haymana and Beyobasi Formation (samples KM3 to KM25) in the east Erif section, NW Haymana (Text-figure 5A). Also, samples 908 to 915 yields the planktonic foraminifera, *Heterohelix* spp., *Guembelitria cretacea, Contusotruncana contusa, C. fornicata, Globotruncana aegyptiaca, G. falsostuarti, G. linneiana, G.* spp., *Globotruncanita conica, G. stuarti, G. stuartiformis, Globotruncanella citae, Abathomphalus mayaroensis, Rugoglobigerina macrocephala* Brönnimann and *Racemiguembelina fructicosa* (Egger) (Text-figure 11A). The planktonic foraminiferal fauna indicates the Zone KS31 or *Abathomphalus mayaroensis* zone due to occurrences of *A. mayaroensis* (Sliter 1989; Caron 1985; Smit 1982; Canude et al. 1991). The middle Hisalköy Formation (samples 916 to 929) yields *Amomalinoides rubiginosus, Conorbitoides cristalensis, Cuvillierina soezerii, C.* spp., *Hellenocyclina beotica, Lepidorbitoides minor, L. socialis*, *L.* spp., *Mississippina binkhorsti, Omphalocyclus macroporus, Orbitoides apiculata, O. gruenbachensis, O. media, O. megaloformis, O. tissoti, Planorbulina cretae, Pseudosiderolites vidali, Rotalia* spp., *Siderolites calcitrapoides, Simplorbites papyraceus, Sirtina orbitoidiformis*, *Sivasella monolateralis, Sulcoperculina dickersoni, Sulcorbitoides pardoi, Broeckinella arabica*, *Pseudolituonella* spp., *Hoeglundina elegans* and *Keramosphaerina* spp. (Text-figures 10A, 10B). This fauna is assigned to the Assemblage 4 due to common occurrences of *Hellenocyclina beotica, Lepidorbitoides socialis, Orbitoides apiculata, Siderolites calcitrapoides, Simplorbites papyraceus*, *Sirtina orbitoidiformis* and *Sivasella monolateralis.* This fauna is correlated with the faunal Assemblage 4 from the Beyobasi Formation (samples KM40 to KM49) in the west Erif section, NW Haymana, and Akveren Formation (samples 801 to 806) in Devrekani, Kastamonu (section 8), Black Sea region, due to common occurrences of *Orbitoides apiculata, Siderolites calcitrapoides, Sirtina orbitoidiformis, Hellenocyclina beotica* and/or *Omphalocyclus macroporus* (Text-figures 5A, 10A). Also, samples 916 to 929 yields the planktonic foraminifera, *Heterohelix* spp., *Contusotruncana contusa, *C. fornicata, Globotruncana aegyptiaca, G. arca, G. esnehensis* Nakkady, *G. falsostuarti, *G. lineiana, G.* spp., *Globotruncanita stuarti, G.*




TEXT-FIGURE 13
Biostratigraphic synthesized occurrence and phylogenetic relationship of main larger and important benthic foraminiferal species from the Haymana and Black Sea regions, Turkey is shown, and these data become the base of the assemblages. However, there are considerable reworking species marked by parenthesis in the Haymana region. The early to middle Eocene Çayraz Formation yields the middle to late Paleocene *Ranikothalia nuttalli* (sample KM11, Text-figure 5B), *Lockhartia conditi* (in sample KM29, Text-figure 5B), and *L. haimei* (in sample KM29, Text-figure 5B) as reworking species. *Nummulites planulatus* (in sample 921011-14, Text-figure 5B) occur in association with middle Eocene *Assilina exponens* and *A. spira* from the top Çayraz Formation, and is naturally reworked. *Assilina exponens* and *A. spira* has partial been washed from the top Çayraz Formation and transported into the lower Cayraz Formation (in samples KM11, 921011-10, 921011-11, and 021011-12; Text-figure 5B). *Assilina dandotica* of the late Paleocene to early Eocene species (Schaub 1981) is found from the lower Çaldağ Formation (sample KM2; Text-figure 5A) and Ilginlikdere Formation (sample KM23; Text-figure 5B), and partial reworked. The early to middle Paleocene *Daviesina danieli* is reworking into the early to middle Eocene Çayraz Formation (in samples KM29, KM11, KM1, 921011-10, 921011-11, and KM43; Text-figure 5B), but is omitted to avoid the further confusion. The Campanian *Planorbulinella dordoniensis* is found from samples KM47, 35, 9 and E1044 (Beyobasi Formation; Text-figure 5B) and KM 2 and 33 (Çaldağ Formation; Text-figure 5A) as reworked species. As such, in the Haymana region, the geological problems created by the depositional environments and tectonic movements have occurred the extensive reworking species in the Beyobasi, Çaldağ, Ilginlikdere, and Cayraz Formations.

*stuartiformis, Abathomphalus mayaroensis, Rugoglobigerina* spp., *Pseudotextularia elegans* and *Racemiguembelina fructicosa* (Text-figures 11A, 11B). This planktonic foraminiferal fauna indicates the Zone KS31 or *Abathomphalus mayaroensis* zone (Sliter, 1989; Caron, 1985). Asterisk species are reworked. Further, the upper Hisalköy Formation (samples 930 to 933) yields *Anomalinoides rubiginosus, *Cuvillierina* soezerii, *C. spp., **Lepidorbitoides* spp., *Mississippina binkhorsti, *Orbitoides tissoti, Planorbulina cretae, *Sirtina orbitoidiformis, Chrysalidina* spp., *Pseudolituonella* spp., *Valvulina* spp., *Hoeglundina elegans*, and *Lenticulina* spp. (Text-figure 10B). Asterisk species are reworked. The present fauna is poor due to the low diversity after the K-T boundary, but is characterized by common occurrences of *Anomalinoides rubiginosus, Mississippina binkhorsti, Planorbulina cretae, Chrysalidina* spp., *Pseudolituonella* spp. and *Hoeglundina elegans.* The present assemblage is assigned to the Assemblage 5 due to common occurrences of above six species. This fauna is regarded as the first larger foraminiferal assemblage of the Cenozoic (early Paleocene) sedimentary rocks in Turkey. Samples 930, 932 and 933 yield the planktonic foraminifera, *Globoconusa* ex gr. *G. daubjergensis* (Brönnimann), *Parvularugoglobigerina* ex gr. *P. eugubina* (Luterbacher and Premoli Silva), *Eoglobigerina* ex gr. *E. fringa* (Subbotina), *Subbotina* spp., *Parasubbotina pseudobulloides, Morozovella* spp., **Globigerinelloides* spp., **Heterohelix* spp., **Contusotruncana contusa, *Globotruncana falsostuarti, *G. linneiana, *G.* spp., **Globotruncanita stuartiformis, *Abathomphalus mayaroensis, *Rugoglobigerina rugosa* and **R*. spp. (Text-figure 11B). Asterisk ten species are reworked. The planktonic foraminiferal fauna indicates the Zones P0-1 (Blow 1969; Berggren and Van Couvering 1974; Smit 1982; Toumarkine and Luterbacher 1985; Canude et al. 1991; Keller 1993; Keller and MacLeod 1994; Berggren et al. 1995; Molina et al. 1996; Anthonissen and Ogg, 2012). The upper Hisalköy Formation (samples 934 and 935) yields *Anomalinoides rubiginosus, Mississippina binkhorsti, Planorbulina cretae, Textularia* spp. and *Hoeglundina elegans* (Text-figure 10B). The present fauna is very poor in the low diversity, but is assigned to the faunal Assemblage 6. Also, samples 934 and 935 yields the planktonic foraminifera, *Subbotina* spp., *Parasubbotina pseudobulloides, P. trinidadensis* and *Morozovella* spp. (Text-figure 11B), and the planktonic foraminifera indicate the zone P2  due to similar fauna with the Akveren Formation (samples 602 to 604) in Kayabogazi, Göynük (section 6) (Text-figures 11A, 11b). The upper Hisarköy Formation (samples 936 and 937) yields only planktonic foraminifera, *Subbotina triloculinoides, Parasubbotina trinidadensis, Morozovella* spp., *M. aequa, M.* spp., *Acarinina* spp., *Globanomalina chapmani* (Parr) and *G. compressa* (Text-figure 11B). This fauna indicates the Zone P3 (Blow 1969; Berggren and Van Couvering 1974; Toumarkine and Luterbacher 1985; Berggren et al. 1995). Then, the present assemblage is tentatively assigned to the faunal Assemblage 7, which is found in the Akveren Formation (sample 204) carring planktonic foraminifera in the Kizderbent, Yalakdere, Karamursel (section 2) (text-figure 11A). The top Hisarköy Formation (composed of alternation of cocoa colored shaly limestone and gray colored shale, sometimes with intercalation of pebble conglomerate; samples 938, 989 and 921015) yields *Anomalinoides rubiginosus, Kathina selveri, Miscellanea globularis, M. primitiva, Mississippina binkhorsti, Planorbulina cretae, Rotalia* spp., *Chrysalidina* spp., *Coskinon rajkae, Pseudolituonella* spp., *Valvulina* spp., *Hoeglundina* elegans, *Idalina sinjarica, Lenticulina* spp. and *Dentalina* spp. (Text-figure 10B). This fauna is assigned to the Assemblage 8 due to common occurrences of *Kathina selveri, Miscellanea globularis, M. primitiva* and *Idalina sinjarica*. Also, samples 938, 939 and 921015 yields the planktonic foraminifera, **Globoconusa* ex gr. *G. daubjergensis, Subbotina triloculinoides, S.* spp., **Parasubbotina pseudobulloides, *P. trinidadensis, Morozovella velascoensis* (Cushman), *M. aequa, M*. spp., *Acarinina* spp., *Globanomalina chapmani* (Parr), *G. pseudomenardii, G.* spp., *Igorina pusilla, *Heterohelix* spp. and **Abathomphalus mayaroensis* (Text-figure 11B). Asterisk species are reworked. The present planktonic foraminiferal fauna indicates the Zone P4 of the Selandian age (Bolli 1969; Berggren and Van

---

**PLATE 1**

1-5. *Chaldagia haymanensis* Matsumaru, n. gen., n. sp. Locality: KM20, Çaldağ, Haymana region. 1-5. ×50.

1 Equatorial sections of megalospheric form, Holotype, Saitama Univ. Coll. No. 201201-1.

2 Equatorial sections of microspheric form, paratype: Saitama Univ. Coll. No. 201201-2.

3-5 Centered oblique sections of megalospheric form.

6-12. *Scandonea samnitica* De Castro

6 Equatorial section of megalospheric form. Locality: 6. KM20, Haymana region. ×20.

7 Subequatorial sections of microspheric form. Locality: KM32, Haymana region.

8 Subequatorial sections of megalospheric form. Locality: KM2, Haymana region. ×20.

9 Transverse sections of three specimens, which are cut each uniserial chambers. Locality: KM46, Haymana region. ×20.

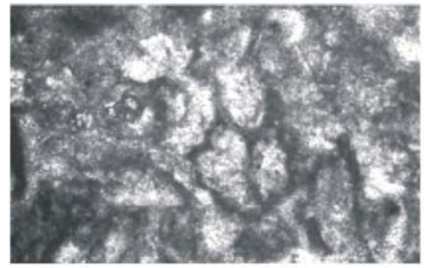
10 Axial section of megalospheric form. Locality: KM7, Çaldağ, Haymana region. ×20.

11 Axial section of microspheric form. Locality: 405, Güneytepe, Black Sea region. ×40.

12 Oblique sections of two specimens. Locality: KM2, Haymana region. ×20.

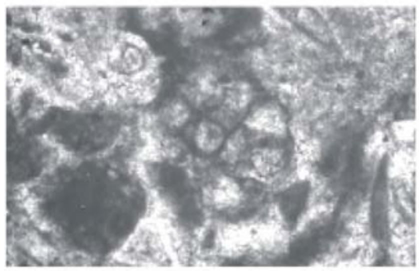
1

2

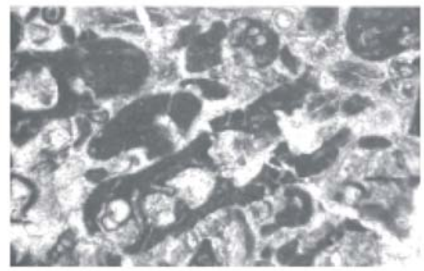


3

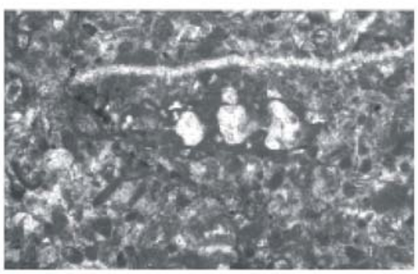
4



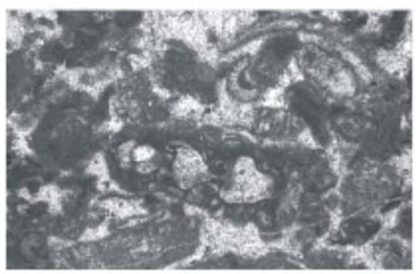
5



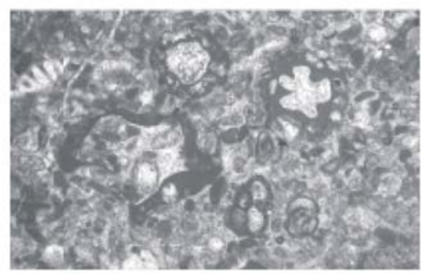
6



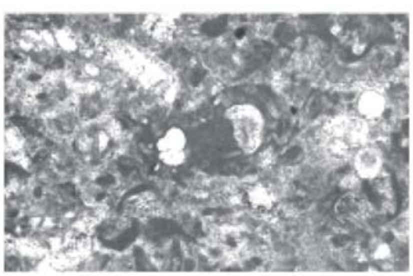
7



8

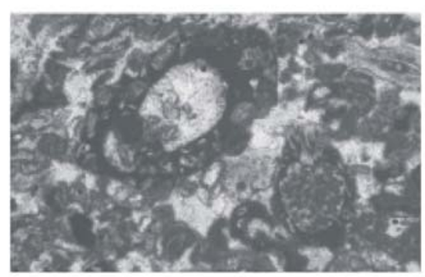


9



10

11



12

Couvering 1974; Toumarkine and Luterbacher 1985; Berggren et al. 1995). Sirel (1973) regarded the Hisalköy Formation to be the Maastrichtian - Danian age, which was overlain by the Thanetian Akgüney Formation. Özcan and Özkan Altner (1999) regarded the Akgüney Formation to be Danian age, although they don't show any positive data. The author surveyed the Cide section twice in 1992 and 1995, and regarded the Hisalköy Formation to be the Flysh type strata, which was composed of the alternation of gray to light gray colored (sometimes orange colored in weathering) massive or banded limestone, compressed pebble bearing sandy limestone, oolite bearing limestone, greenish gray to cocoa colored calcareous shales and mudstones and pebble conglomerate. The age of the Hisarköy Formation was assigned to the Maastrichtian to Selandian based on the larger and planktonic foraminifera as stated above (Text-figures 11A-11B). The K-T boundary layers of the Hisarköy Formation are placed at near and at right angles to the corner between the north – south uphill road from Cide Town to Sinop City and east-west road parallel along the Black Sea toward eastern Sinop City, and put on the limestone between the gray colored muddy limestone (sample 929) and cocoa colored banded sandy limestone (sample 930). Along the descent down road from the boundary to Cide Town, the alternation of shaley-muddy limestone and mediam grained sandstone of the Hisalköy Formation is developed, and samples 936 to 921915 were collected from the Hisalköy Formation. Sample 938 is placed at the transmission of electricity pole beside the road. Samples 938 to 921915 are collected from the top Hisalköy Formation, which is bounded by the fault with the folding Akgüney Formation (composed of the alternation of gray colored mudstone and limestone). The Hisarköy Formation (samples 901 to 921015) in the Cide section is correlated well with the Mahadeo Formation (samples W-73 to W-14) to Langpar Formation (samples W-15 to W-52) in the main Um Sohryngkew River section and partial Mawsmai section, 5 km NW from the Um Sohryngkew River section, both of Meghalaya, NE India (Pandey 1981, fig. 1; Pandey 1990, fig. 1), based on benthonic and planktonic foraminifera. The K-T Ir bearing goethite layers didn't found in the upper Hisarköy Formation (samples 929 to 930) in the Cide section. The upper Hisarköy Formation (samples 930 to 933) of the Zones P0-1 of planktonic foraminiferal zones above the K-T boundary is,

---

**PLATE 2**

1-3. *Pseudosiderolites vidali* (Douvillé)

1 Subaxial section of microspheric form. Locality: 1. 913 and 3. 924, Cide, and 2. 801, Devrekani, all of Black Sea region. ×20.

2 Oblique section of megalospheric form in center, associated with *Cuvillierina soezerii* (Sirel) in left and right. Locality: 1. 913 and 3. 924, Cide, and 2. 801, Devrekani, all of Black Sea region. ×20.

3 Subequatorial section of megalospheric form. Locality: 1. 913 and 3. 924, Cide, and 2. 801, Devrekani, all of Black Sea region. ×20.

4-5. *Helicorbitoides voigti* Van Gorsel

4 Centered oblique sections of megalospheric form, showing a few arcuate secondary equatorial chambers between first and second whorls of primary nepionic spiral. ×50.

5 Transverse section of microspheric form. Locality: sample loc. 734, Bole, Black Sea region (Sirel 1995, fig. 1; Text-fig. 1). ×20.

6-7. *Helicorbitoides longispiralis* (Papp and Küpper)

6 Centered oblique sections of microspheric form (6) and showing probably two more whorls of primary spiral, and later continuing arcuate equatorial chambers radially. Locality: 734, Siyamoğle, Black Sea Region. ×20.

7 megalospheric form, showing probably two more whorls of primary spiral, and later continuing arcuate equatorial chambers radially. Locality: 909, Cide, Black sea region. ×20.

8-9. *Lepidorbitoides pembergeri* Papp

8 Centered oblique section of megalospheric form. Locality: 8. W-1, Haymana region. ×40.

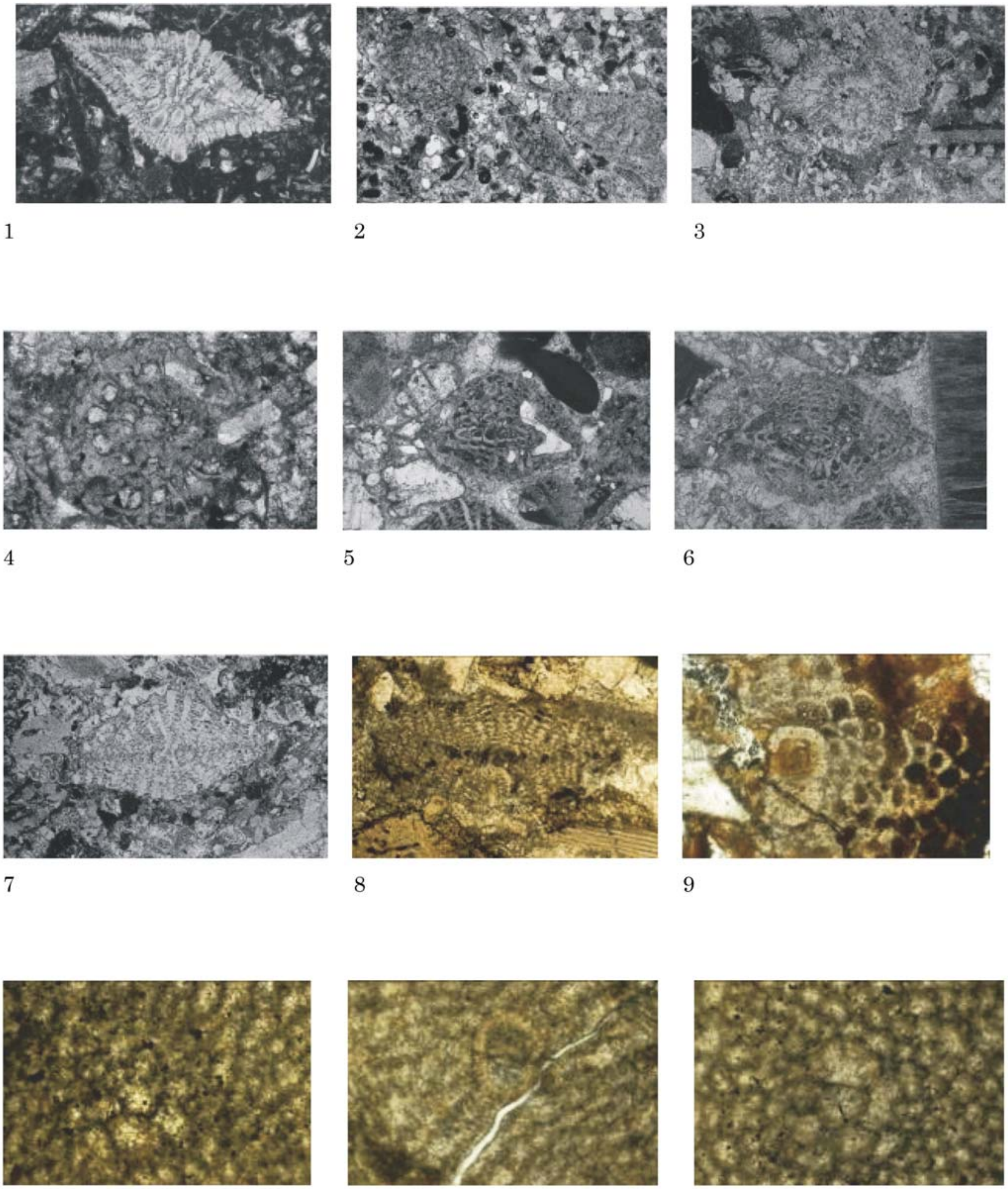
9 Equatorial section of megalospheric form, showing ill-balanced biserial nepionic arrangement of unrolling long primary (helicolepidine) spiral starting along protoconch and unrolling short primary spiral in opposite direction starting along deuteroconch. Locality: W-2 (Ozcan and Altiner 1992, fig. 1), Haymana region. ×80.

10-11. *Lepidorbitoides campaniensis* Van Gorsel

10 Equatorial section of megalospheric form. Locality: W-2 (Ozcan and Altiner 1992, fig. 1), Haymana region. ×80.

11 Centered oblique section of megalospheric form. Both forms showing biserial peri-embryonic arrangement of nepionic spirals, long primary nepionic spiral along protoconch and short primary nepionic spiral along deuteroconch. Locality: W-2 (Ozcan and Altiner 1992, fig. 1), Haymana region. ×80.

12. *Lepidorbitoides bisambergensis* (Jaeger). Equatorial section of megalospheric form showing a quadriserial nepionic arrangement, without any accessory auxiliary chambers on deuteroconch. Locality: W-2 (Ozcan and Altiner 1992, fig. 1), Haymana region. ×80.


1
2
3
4
5
6
7
8
9
10
11
12

however, correlated with the basal Salvipinari Formation (sample 504), which overlies the K-T Ir layers (0.24 ppb by Arakawa et al. 2003) of the top Taraklı Formation in Medetlı (section 5) as stated above (Matsumaru et al. 1996, 1997; Arakawa et al. 2003, 2007; Text-figure 7). The K-T Ir boundary layers of the top Taraklı Formation below the Salvipinari Formation is correlated well with the K-T iridium layers (12 ppb by Bhandari et al. 1998, 1994; 4.1 ppb by Murali et al. 1990) of the top Mahadeo Formation, Um Sohryngkew River section, Meghalaya, NE India, based on the chemistratigraphy (Ir and siderophiles). The upper Mahadeo Formation (samples W-3 to W-7 and J85-25) below the Ir bearing K-T limonite layers in the Um Sohryngkew River section, Meghalaya, NE India indicate the Maastrichtian *Globotruncanita stuartiformis* Zone without *Abathomphalus mayaroensis* (Pandey 1981, p. 57; 1990, fig. 1c), and also the topmost Mahadeo Formation (about 1m thick; samples S10 to S30) right below the K-T Ir layers indicate the terminal Maastrichtian calcareous nannofossil *Micula prinsii* zone (Garg and Jain 1995; Kar et al. 2006, fig. 2; Anthonissen and Ogg 2012, p. 1119). In there, the top Mahadeo Formation (sample J85-32), 1.5 m above the K-T Ir layers yields *Parvulalgoglobigerina eugubina* (Pandey 1990, figs. 1c, 2h) of the Zones P0-1 of planktonic foraminiferal zones, and the Langpar Formation (sample W 27), about 33 m above the K-T Ir layers yield *Parasubbotina inconstans* (Pandey 1990, figs. 1, 2i) of the Zones P1-2. In addition, the upper Mahadeo Formation (sample W4), about 10 m below the K-T Ir layers yields *Navarella joaguini* (Pandey 1981, p. 57, fig. 1, pl. 1, figs. 7-9). This species is known in the Assemblage 3 and the lower part of the Zone KS31 of planktonic foraminiferal zones in Turkey (Text-figure 13; Plate 8, figures 11-12). *Navarella joaguini* don't seem to survive into the *Globotruncanita stuartiformis* zone in the top Mahadeo Formation (Pandey 1981, p. 57). Also, the Langpar Formation (samples W23 to W35), about 25 to 38 m above the K-T Ir layers yielded *Anomalinoides rubiginosus* (Pandey 1990, fig. 1a). This species is known in the Assemblages 2 to 8 and Zones KS 28? to P 5 of planktonic foraminiferal zones in Turkey (Text-figure 13; Plate 10, figs. 2-3).

**10. Kokaksu Section, Zongludak** (Text-figures 1, 7). The lower Akveren Formation (sample 1001) yields *Minouxia* spp. and planktonic foraminifera, *Globigerinelloides* spp., *Heterohelix* spp., *Contusotruncana contusa*, *C. fornicata, Globotruncana arca*, *G. linneiana, G.* spp., *Globotruncanita stuarti, G. stuartiformis, Rugoglobigerina rugosa, R.* spp.,

**PLATE 3**

1. *Lepidorbitoides minor* (Schlumberger). Equatorial section of megalospheric form, showing 8 nepionic spirals of chamber arrangement due to having two accessory auxiliary chambers on deuteroconch. Locality: 909, Cide, Black Sea region. ×50. Scale is 1000 micron.

2-3. *Lepidorbitoides socialis* (Leymerie)

2 Equatorial sections of megalospheric form, showing multi-nepionic spirals, and having more than five accessory auxiliary chambers on deuteroconch. Locality: KM3, Haymana region. ×30. Scale is 1000 micron.

3 Equatorial sections of megalospheric form, showing multi-nepionic spirals, and having more than five accessory auxiliary chambers on deuteroconch. Locality: 928, Cide, Black Sea region. ×30. Scale is 1000 micron.

4-8. *Pseudorbitoides trechmanni* Douvillé

4 Equatorial sections of microspheric form, associated with *Orbitoides* spp. Locality: 902, Black Sea region. ×20.

5 Equatorial sections of microspheric form, associated with *Orbitoides* spp. showing small spiral of primary chambers and equatorial chambers subdivided by pseudorbitoid layer of radial elements. Locality: 902, Black Sea region. ×50.

6 Tangential section. Locality: W-3 (Ozcan and Altiner 1992, fig. 1), Haymana region. ×70.

7 Axial sections of megalospheric form (7 left), microspheric form (7 right). Locality: 908, Black Sea region. ×20.

8 microspheric form carrying radial elements (center), associated with *Orbitoides* spp. (left) and *Contusotruncana contusa* (Cushman) (right). Locality: 903, Cide, Black Sea region. ×30.

9-10, 12 center and right. *Conorbitoides cristalensis* Brönnimann

9 Axial section. Locality: 912, Black Sea region. ×110.

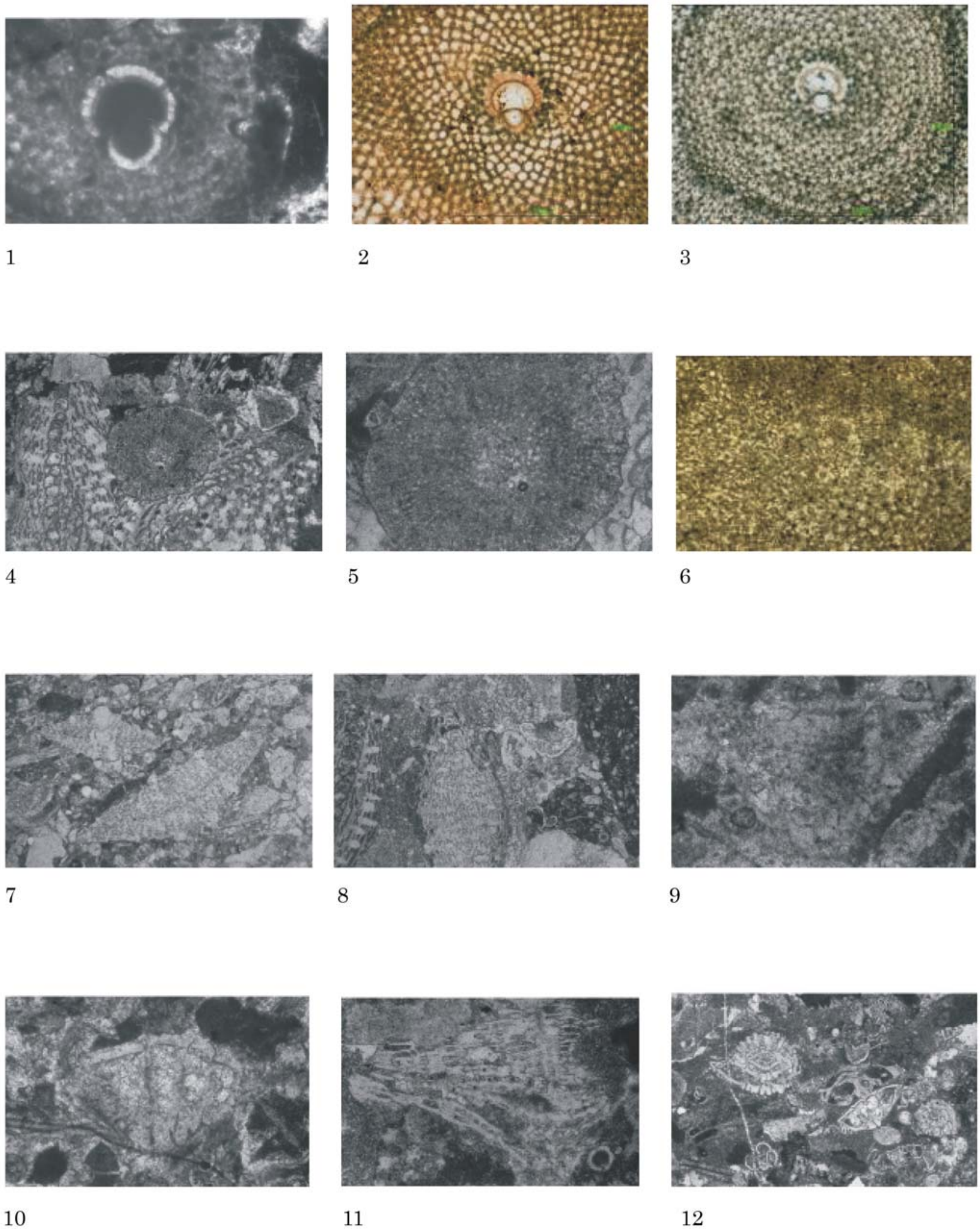
10 Transverse section. 910, Cide, Black Sea region. ×40.

12 center Transverse section. 910, Cide, Black Sea region.

12 right Equatorial section of microspheric form, associated with *Sirtina orbitoidiformis* Brönnimann and Wirz (12 left) and *Globotruncana aegyptiaca* Nakkady (12 right lower). Locality: 910, Cide, Black Sea region. ×20.

11. *Clypeorbis mammillatus* Brönnimann. Vertical section. Locality: 910, Cide, Black sea region. ×40.

12 left. *Sirtina orbitoidiformis* Brönnimann and Wirz. Axial section of microspheric form, associated with *Conorbitoides cristalensis* Brönnimann in center and right, and *Globotruncana aegyptiaca* Nakkady in right lower. Locality; 909, Cide, Black Sea region. ×20.


1
2
3
4
5
6
7
8
9
10
11
12

*Gansserina gansseri, Pseudotextularia elegans, Racemiguembelina fructicosa*, *Rugotruncana subpenny* and *R*. spp. (Text0figures 10B, 11B). This fauna indicates the Zone KS30 due to occurrences of *G. arca, G. stuartiformis* and *G. gansseri*. Also, the lower Akveren Formation (samples 1002 to 1005) yields *Navarella joaguini, Hoeglundina elegans,* and planktonic foraminifera, *Heterohelix* spp., *Guembalitria cretacea, Contusotruncana fornicata, Globotruncana falsostuarti, G. linneiana, G.* spp., *Globotruncanita stuarti, Globotruncanella citae, G. petaloidea* (Gondolfi), *Abathomphalus mayaroensis, A. intermedius* (Bolli), *Rugoglobigerina macrosephala, R. rugosa, R. scotti, R.* spp., *Pseudotextularia elegans, Racemiguembalina fructicosa,*and *Rugotruncana subpenny* (Text-figures 10B, 11B). The present fauna is assigned to the Assemblage 3 due to occurrences of *Navarella joaguini* and *Hoenglundina elegans*, and indicates *Abathomphalus mayaroensis* zone (KS31) (Sliter 1989; Caron 1985). The upper Akveren Formation (sample 1006) yields planktonic foraminifera, *Parvulargoglobigerina* ex gr. *P. eugubina, Eoglobigerina* ex gr. *E. fringa, Subbotina triloculinoides, Parasubbotina pseudobulloides, P. trinidadensis, Praemurica* ex gr. *P. inconstans, Globanomalina compressa, G. pentagonalis* (Morozova), **Globotruncana* spp., **Globotruncanita conica, *Globotruncanella citae, *G.* spp., and **Rugoglobigerina* spp. (Text-figure 11B). Asterisk species are reworked. The fauna indicates the Zones P0-1 (Toumarkin and Luterbacher 1985; Molina et al. 1996). The upper Akveren Formation (sample 1007) yields planktonic foraminifera, *Morozovella* spp. and **Globotruncana* spp. Asterisk species is reworked. This is tentatively assigned to the Assemblage 6 due to the stratigraphy. The upper Akveren Formation (samples 1008 to 1014) yields *Daviesina danieli, D. langhami, Miscellanea primitiva,* **Hellenocyclina beotica, Rotalia trochidiformis, Broeckinella arabica, Coskinon rajkae,* **Minouxia* spp., *Textularia* spp., *Valvulina* spp., *Idalina sinjarica,* and *Lenticulina* spp. (Text-figure 10B). Asterisk two species are reworked. The present fauna is assigned to the faunal Assemblage 7, based on occurrences of *Daviesina danieli, D. langami, Miscellanea primitiva, Rotalia trochidiformis* and *Idalina sinjarica* (Text-figure 3). This fauna is correlated to the faunal Assemblage 7 from the Çaldağ Formation (samples KM2 to KM44) in the Çaldağ section, west Haymana; Çaldağ Formation (samples KM31 to KM36) in the west Erif section; Çaldağ Formation (samples E1033 to E1031) in the east Erif section; Çaldağ Formation (samples KM8 to KM18) in the Bahçecik section, south Haymana; Yaghane Formation (sample 204) in Kizderbent, Yalakdere, Karamursel (section 2); and upper Hisalköy Formation (samples 936 and 937) in Cide (section 9). Also, the upper Akveren Formation (samples 1008 to 1014) in the Kokaksu, Zongludak section (section 10) yield the planktonic foraminifera, **Globoconusa* ex gr. *G. daubjergensis, *Parvulargoglobigerina* ex gr. *P. eugubina, Subbotina triloculinoides, S.* spp., *Parasubbotina pseudobulloides, *P. trinidadensis, Morozovella* spp., *Acarinina* spp., *Globanomalina chapmani, G. compressa, *Guembelitria cretacea, *Contusotruncana fornicata, *Globotruncana aegyptiaca, *G. arca, *G. linneiana, *G.* spp., **Globotruncanita stuarti, *Abathomphalus mayaroensis, *Rugoglobigerina macrocephala, *R. rugosa, *R.* spp. and **Racemiguembelina fructicosa* (Text-figure 11B). Asterisk fifteen species are reworked. The planktonic foraminiferal fauna indicates the Zone P3 (Blow 1969; Berggren and Van Couvering 1974; Toumarkine and Luterbacher 1985; Berggren etal. 1995). The top Akveren Formation (samples 1015 and 1016) yields the planktonic foraminifera, **Globoconusa* ex gr. *G. daubjergensis, Subbotina triloculinoides, S*. spp., *Morozovella velascoensis, M. aequa, M. spp., Acarinina mckannai, A*. spp., *Globanomalina chapmani, G. pseudomenardii,* and *Igorina pusilla* (Text-figure 11B). Asterisk species is reworked.

## PLATE 4

1-4. *Sirtina orbitoidiformis* Brönnimann and Wirz

1 Axial section of megalospheric form. Locality: 925, Black Sea region. ×50.

2 Transverse section of microspheric form. 926, Cide, Black Sea region. ×50.

3 Oblique section. 104, Tavşantepe, Black Sea region. ×50.

4 Centered oblique section. Locality: 925, Black Sea region. ×40.

5-7. *Sulcoperculina dickersoni* (Palmer)

5 Axial section of microspheric form. Locality: 908, Black Sea region. ×60.

6 Equatorial section of megalospheric form. Locality: 908, Black Sea region. ×60.

7 Centered oblique section of megalospheric form. Locality: 904, Cide, Black Sea region. ×30.

8-11. *Sulcorbitoides pardoi* Brönnimann

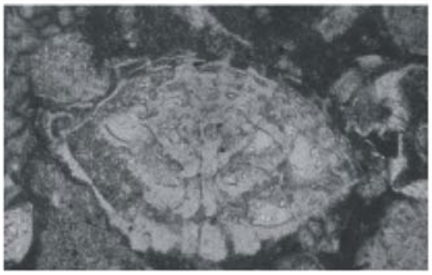
8 Axial section of microspheric form. Locality: 915, Black sea region. ×100.

9 Oblique section. Locality: 904, Black sea region. ×50.

10 Transverse section. Locality: E1033.5, East Erif, Haymana region. ×20

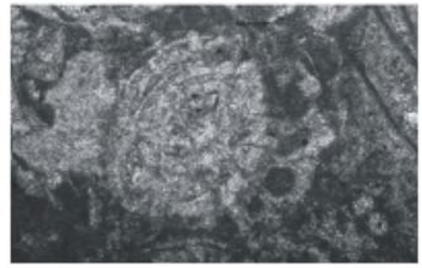
11 Equatorial section of microspheric form. Locality: 926, Cide, Black sea region. ×60.

12. *Hellenocyclina beotica* Reichel. Equatorial section.Locality: KM25, East Erif, Haymana region. ×50.

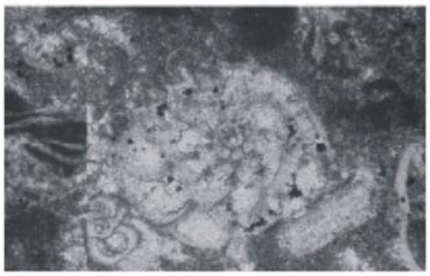


1

2



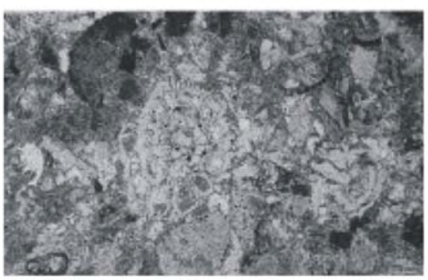
3



4

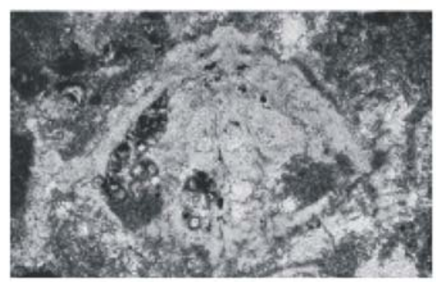
5

6



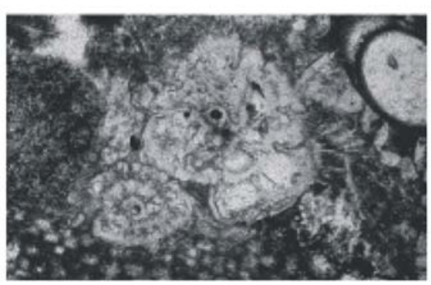
7

8

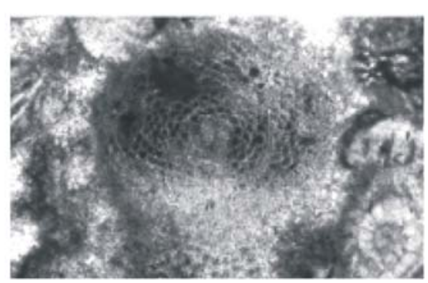


9

10



11



12

The planktonic foraminiferal fauna indicates the Zone P4 (Blow 1969; Berggren and Van Couvering 1974; Toumarkine and Luterbacher 1985; Berggren et al. 1995).

**12. Avdal Section, Agva** (Text-figures 1, 7). The lower Akveren Formation (samples 1220 to 1227) yields *Sirtina orbitoidiformis* and *Navarella joaguini* (Text-figure 10B). The fauna is very poor in the low diversity, but is assigned to the Assemblage 3 due to occurrence of *Navarella joaguini*. Also, these samples yield the planktonic foraminifera, *Contusotruncana contusa, C. fornicata, Globotruncana esneensis, G. falsostuarti, G. linneiana*, *G.* spp., *Globotruncanita conica, G. stuarti, G. stuartiformis, Abathomphalus mayaroensis, Rugoglobigerina rugosa, R*. spp. and *Gansserina gansseri* (Text-figure 11B). The planktonic foraminiferal fauna indicates the Zone KP31 or *Abathomphalus mayaroensis* zone (Sliter 1989; Caron 1985). The upper Akveren Formation (samples 1228 to 1235) yields *Kathina selveri, Miscellanea globularis*, *Planorbulina create, Rotalia* spp., **Sirtina orbitoidiformis, Sistanites iranica, Pseudochrysalidina* spp., *Pseudolituonella* spp., *Textularia* spp., *Hoeglundina elegans,* and *Lenticulina* spp. (Text-figure 10B). Asterisk species is reworked. The present fauna is assigned to the Assemblage 6 due to common occurrences of *Kathina selveri, Miscellanea globularis* and *Hoeglundina elegans*. Also these samples yield the planktonic foraminifera, **Globoconusa* ex gr. *G. daubjergensis, *Parvulalgoglobigerina* ex gr. *P. eugubina, *Eoglobigerina* ex gr. *E. fringa, Subbotina triloculinoides, S*. spp., *Parasubbotina pseudobulloides, P. trinidadensis, Praemurica* ex gr. *P. inconstans, P.* ex gr. *P. uncinata, Morozovella* spp., *Globanomalina compressa, G.* spp., **Heterohelix* spp., **Guembelitria cretacea, *Globotruncana linneiana, *G.* spp., **Globotruncanita conica, *G. stuarti, *Rugoglobigerina* spp. and **Gansserina gansseri* (Text-figure 11B). Asterisk eleven species are reworked. The planktonic foraminiferal fauna indicates the Zone P2 (Blow 1969; Berggren and Van Couvering 1974; Toumarkine and Luterbacher 1985; Berggren et al. 1995).

**13. Yeşilçay Section, Agva** (Text-figures 1, 7). The lower Akveren Formation (samples 1301 and 1302) yields *Anomalinoides rubiginosus* and *Navarella joaguini* (Text-figure 10B). This fauna is assigned to the Assemblage 3 due to occurrencs of *Navarella joaguini*. Also, both samples yield *Globotruncana* spp. (Text-figure 11B). The upper Akveren Formation (samples 1303 and 1304) yields *Anomalinoides rubiginosus* (Text-figure 10B), and also yield the planktonic foraminifera, *Subbotina* spp., *Morozovella* spp. and *Globanomalina compressa* (Text-figures 10B, 11B). The planktonic foraminiferal fauna indicates the Zone P3 (Blow 1969; Berggren and Van Couvering 1974; Toumarkin and Luterbacher 1985; Berggren et al. 1995). The present fauna will be assigned to the Assemblage 7, because the Zone P3 is found in the

**PLATE 5**

1-2. *Sivasella monolateralis* Sirel and Gündüz

1 Transverse section of microspheric form, showing lack of lamellar wall on the dorsal side toward the periphery. Locality: W-1 (Ozcan and Altiner 1992, fig. 1), Haymana region. ×100.

2 Vertical section of megalospheric form, showing no lamellar wall on the dorsal side of the test, although *Sivasella* carry the thick lamellar wall on the dorsal side of the test. Locality: W-1 (Ozcan and Altiner 1992, fig. 1), Haymana region. ×80.

3-5. *Planorbulina cretae* (Marsson)

3 Vertical section. Locality: KM47, Çaldağ, Haymana Region.

4 Centered oblique section of megalospheric form. Embryonic chambers are followed by spirally arranged nepionic chambers. Locality: E1033, East Erif, Haymana region.

5 Centered oblique section of megalospheric form. Embryonic chambers are followed by spirally arranged nepionic chambers. Locality: 935, Cide, Black Sea region. ×50.

6-8. *Planorbulinella dordoniensis* Hofker

6 Subtransverse section. Locality: KM35, Haymana region. ×50.

7 Centered oblique sections of megalospheric form. Locality: KM2, Çaldağ, Haymana region. ×50.

8 Centered oblique sections of megalospheric form. Embryonic chambers of megalospheric form are followed by biserial arrangement of nepionic chambers. Locality: KM33, East Erif, Haymana region. ×50.

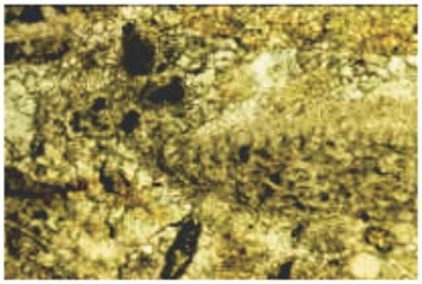
9. *Siderolites calcitrapoides* Lamarck. Equatorial section of microspheric form. Locality: KM3, Haymana region. ×20.

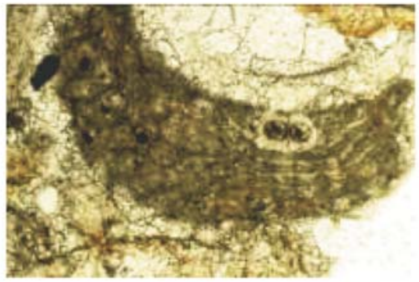
10-11. *Orbitoides tissoti* Schlumberger

10 Centered oblique section of megalospheric form, showing the value of Van Hinte (1966)'s Li + li embryo diameter of 256 micron. Large coarse spines of *Siderolites calcitrapoides* can be seen (lower right). 902, Cide, Black Sea region. ×10.

11 Centered oblique section of megalospheric form, showing the value of Van Hinte (1966)'s Li + li embryo diameter of 422 micron. Locality: 903, Cide, Black Sea region. ×20.

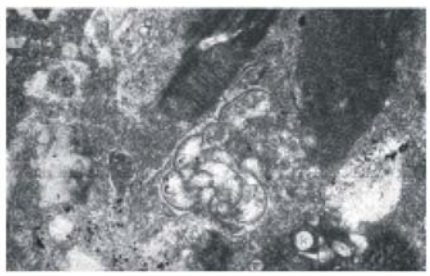
12. *Orbitoides media* (d'Archiac). Centered oblique section of megalospheric form (Van Hinte's Li + li embryo diameter = 592 micron). Locality: KM34, Çaldağ, Haymana region. ×20.

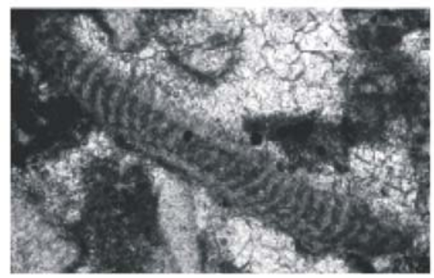

1

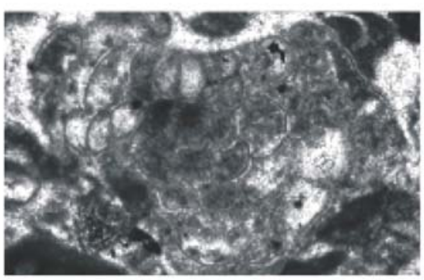

2

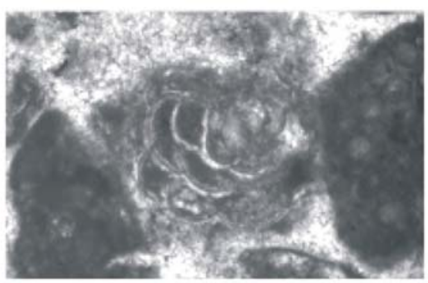

3

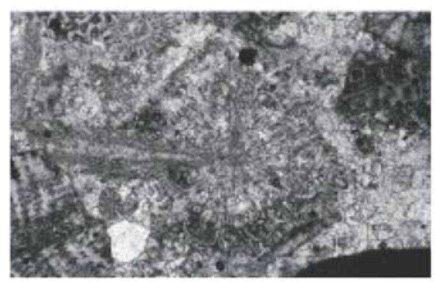

4


5


6

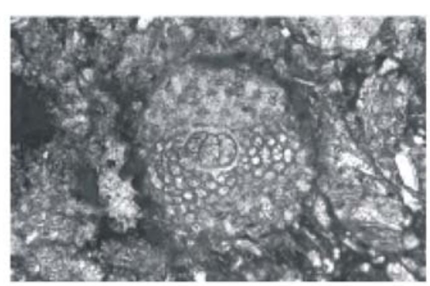

7


8


9


10


11


12

Akveren Formation (samples 1008 to 1014) carrying Assemblage 7 in the Kokaksu, Zongludak (section 10).

**Spot sample 734** (Sirel 1995) (Text-figure 1). The author visited the type locality of *Helicorbitoides boluensis* Sirel 1995, which is described from samples at Mendenler village (present Sabunlar köyü/village), 9.5 km north of Dirgine town, NE Bolu on September 11 and 12, 1999 with Dr. Kemar Erdoğan, M.T.A. We couldn't, however, find the *Helicorbitoides*-bearing limestone (sample no. 734) of the Turonian - Campanian Buldandere Formation. The author was, however, given a few samples for study from Dr. Ercument Sirel, who analysed samples from M.T.A.collection. The limestone sample 734 yields *Helicorbitoides voigti* Van Gorsel, *H. longispiralis, Orbitoides media, O. tissoti* and *Pseudosiderolites vidali* (Text-figure 10B) together with *Globotruncanita stuartiformis* (Text-figure 11B). Sirel (1995) established *Helicorbitoides boluensis* based on the characters of wide primary whorls and many secondary equatorial chambers. But *H. voigti* and *H. longispiralis* are presented in sample 734 as stated above (Plate 2, figures 4-5; Plate 2, figure 6). Further, *Helicorbitoides longispiralis* (Plate 2, figure 7) was found at the first time from the lower Hisalköy Formation (sample 909) in the Cide section, although it has been reworked (Text-figure 10A). The stratigraphic relationship between the Buldandere Formation in Bolu and the Hisalköy Formation in the Cide section is obscure. According to Van Gorsel (1975), the descendant of *Helicorbitoides longispiralis* is *Lepidorbitoides pembergeri* Papp from the upper Campanian beds. *Lepidorbitoides pembergeri* (Plate 2, figures 8-9) was found at the first time in this study from samples W-1 and W-2 of the Campanian Haymana Formation together with *Lepidorbitoides campaniensis* and *L. bisambergensis* (Text-figures 4, 5B; Plate 2, figures 10-11; Plate 2, figure 12). As such, the evolutionary trend in the *Helicorbitoides – Lepidorbitoides* lineage from *Helicorbitoides voigti* through *Helicorbitoides longispiralis* and *Lepidorbitoides pembergeri* to *L. campaniensis* and *L. bisambergensis* during the late Campanian to early Maastrichtian will have to be existed. It needs the further study from many samples of the Unit C, Haymana Formation in Haymana, Hisarköy Formation in Cide and Buldandere Formation in Bolu.

## FAUNAL ASSEMBLAGE ZONATIONS AND THEIR GEOLOGICAL AGES

11 larger foraminiferal assemblage zonations have been recognized from the biostratigraphical occurrences of larger benthonic foraminiferal species, associated with planktonic foraminifera from the best selected sections and samples in the Haymana and Black Sea regions. From 73 samples in the Haymana region, 101 species with one new species belonging to 57 genera with one new genus of larger and benthonic species were identified (Text-figures 5A, 5B). From 105 samples in the Black Sea region, 62 species belonging to 47 genera of larger

## PLATE 6

1-2. *Orbitoides media* (d'Archiac)

1 Equatorial section of megalospheric form (Van Hinte's Li +li embryo diameter = 572 micron). Locality: 1. KM3, East Erif, Haymana region. ×30. Scale is 1000 micron.

2 Centered oblique section of megalospheric form (Van Hinte's Li +li embryo diameter = 582 micron). Locality: 906, Cide, Black Sea region. ×20. Scale is 1000 micron.

3-5. *Orbitoides megaloformis* Papp and Küpper

3 Centered oblique section of megalospheric form (Li + li embryo diameter = 656 micron). Locality: 806, Devrekani, Black Sea Region. ×20. Scale is 1000 micron.

4 Centered oblique section of megalospheric form (Li + li embryo diameter = 691 micron). Locality: 902 Cide, Devrekani, Black Sea Region. ×20. Scale is 1000 micron.

5 Equatorial section of megalospheric form (Li + li embryo diameter = 687 micron). Locality: KM3, East Erif, Haymana region. ×30. Scale is 1000 micron.

6-8. *Orbitoides gruenbachensis* Papp

6 Equatorial section of megalospheric form (Li + li embryo diameter = 936 micron). Locality: 928, Cide, Black Sea region. ×20. Scale is 1000 micron.

7 Equatorial section of megalospheric form (Li + li embryo diameter = 880 micron). Locality: KM3, East Erif, Haymana region. ×20. Scale is 1000 micron.

8 Equatorial section of megalospheric form (Li + li embryo diameter = 821 micron). Locality: KM3, East Erif, Haymana region. ×30. Scale is 1000 micron.

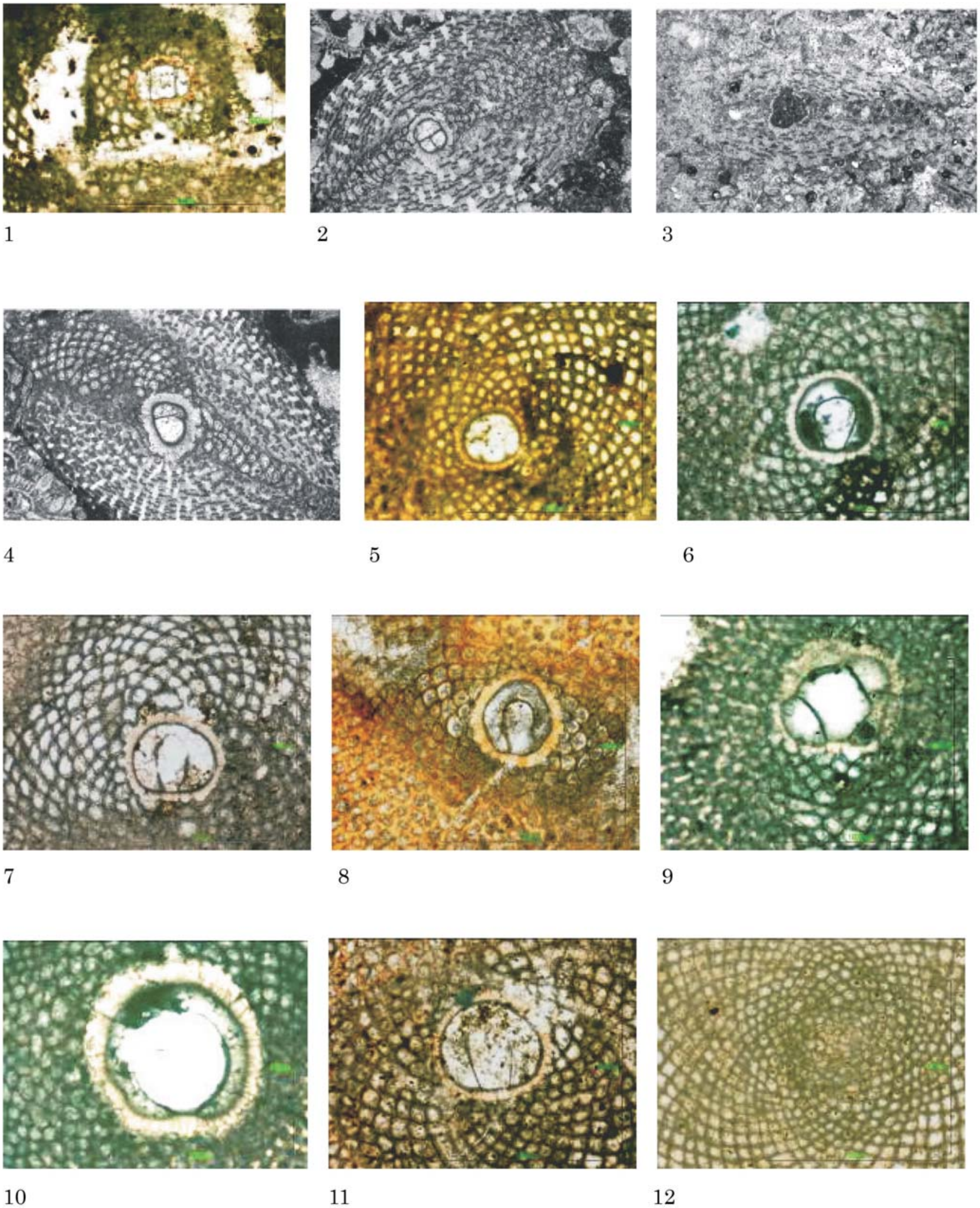
9-11. *Orbitoides apiculata* Schlumberger

9 Equatorial sections of megalospheric form (Li + li embryo diameter = 1161 micron). Locality: 928, Cide, Black Sea region. ×30. Scale is 1000 micron.

10 Equatorial sections of megalospheric form (Li + li embryo diameter = 1560 micron). Locality: 928, Cide, Black Sea region. ×30. Scale is 1000 micron.

11 Equatorial sections of megalospheric form (Li + li embryo diameter = 1113 micron). Locality: KM3, East Erif, Haymana region. ×30. Scale is 1000 micron.

12. *Orbitoides* spp. Equatorial section of microspheric form, showing proloculus, early biserial nepionic spirals of chamber arrangement and later arcuate median chambers. Locality: KM3, East Erif, Haymana region. ×30. Scale is 1000 micron.


1
2
3
4
5
6
7
8
9
10
11
12

and important benthonic foraminiferal species were identified (Text-figures 10A, 10B). As such, the total 114 species (49 common species) with one new species belonging to 66 genera (38 common genera) with one new genus of larger and benthonic forasminifera were identified. These taxa have been found from total 178 samples (73 samples in the Haymana region; 105 samples in the Black Sea region) in total 19 sections (7 sections in the Haymana region; 12 sections in the Black Sea region). The biostratigraphic synthesized occurrence of age-diagnostic larger and benthonic foraminifera (89 species with 8 reworked species) is shown in Text-figure 13. From 32 samples in the Hyamana region, 30 species belonging to 17 genera of the planktonic foraminiferal species, associated with larger foraminifera were identified (Text-figures 6A, 6B). From 67 samples in the Black Sea region, 52 species belonging to 23 genera of the planktonic foraminiferal species, associated with larger and benthonic foraminifera were identified (Text-figures 11A, 11B). The Letter Stages (Matsumaru 2011) from the middle Paleocene (Selandian) and middle Eocene (Lutetian) and Planktonic foraminiferal zones from the late Cretaceous (late Campanian) to late Paleocene (Thanetian) are shown on Text-figures 12 and 13 based on a correlation between the larger and planktonic foraminiferal fauna from the Haymana and Black Sea regions and planktonic foraminifera tropical-temperate zones (Sliter 1989; Caron 1985; Blow 1969; Postuma 1971; Berggren and Van Couvering 1974; Toumarkin and Luterbacher 1985 and Berggren et al. 1995). The planktonic foraminiferal zones from the early Eocene (Ypresian) to middle Eocene (Lutetian) are assumed based on a correlation between the larger foraminiferal zones of the present study, those of Meghalaya, NE India (Matsumaru and Sarma 2010); and those of the Philippines (Matsumaru 2011); and references of well-defined range of larger and benthonic foraminiferal taxon (Bignot and Neumann 1991; Loeblich and Tappan 1988; Serra-Kiel et al. 1998).

The author has examined many samples from the upper Cretaceous to Paleogene sedimentary sequences in the Haymana and Black Sea regions, but a stricter definition of the larger foraminiferal assemblage zones couldn't be thoroughly defined the boundaries in the type sections, due to limited samples, calcification of species by diagenesis and problems of reworked-transported species. The last problems are very important to note, because it is made from more complicated geology created by various depositional environments and tectonic events in both regions. The result of the present study indicates, nevertheless, that the larger foraminifera from 12 formations (Beyobasi, Haymana, Kakarca, Hisalköy, Çaldağ, Yesilyurt, Ilginlikdere, Çayraz, Yaghane, Salvipinari, Halidiye and Akveren Formations) can be grouped into the following eleven assemblage zones in upward sequences:

**Assemblage 1: *Orbitoides tissoti* Schlumberger – *O. media* (d'Archiac) – *O. megaloformis* Papp and Küpper – *O. gruenbachensis* Papp – *Lepidorbitoides campaniensis* Van Gorsel – *L. bisambergensis* (Jaeger) – *Pseudosiderolites vidali* (Douvillé).**

The seven defining species of this assemblage(Assemblage 1) occur in a composite fauna derived from samples W1 and W2 of the thick-bedded turbiditic sandstone (Özgan and Özgan Altiner 1997's unit C) intercalated in shales/marls of the Haymana Formation along the route of and around Haymana, Turkey (Text-figures 2, 4, 5B). The Assemblage 1 is defined by the occurrence of above seven species. The other species that occur in

**PLATE 7**

1-2. *Omphalocyclus macroporus* (Lamarck)

1 Vertical section of megalospheric form. Locality: 1. 915, Cide, Black Sea Region. ×20.

2 Equatorial section of megalospheric form. Locality: 804, Devrekâni, Black Sea region. ×50.

3. *Simplorbites papyraceus* Boubée. Centered oblique section of megalospheric form. Locality: 924, Cide, Black Sea region. ×20.

4. *Hoeglundina elegans* (d'Orbugny). Centered oblique section. Locality: 909, Cide, Black Sea region. ×50.

5. *Nummofallotia cretacea* (Schlumberger). Centered oblique section of megalospheric form. Locality: E1033.5, East Erif, Haymana region. ×100.

6-10. *Cuvillierina soezerii* (Sirel)

6 Centered oblique section of megalospheric form. Locality: 6. 925, Black Sea Region. ×50.

7 Centered oblique section of microspheric form. Locality: 802, Black Sea Region. ×20.

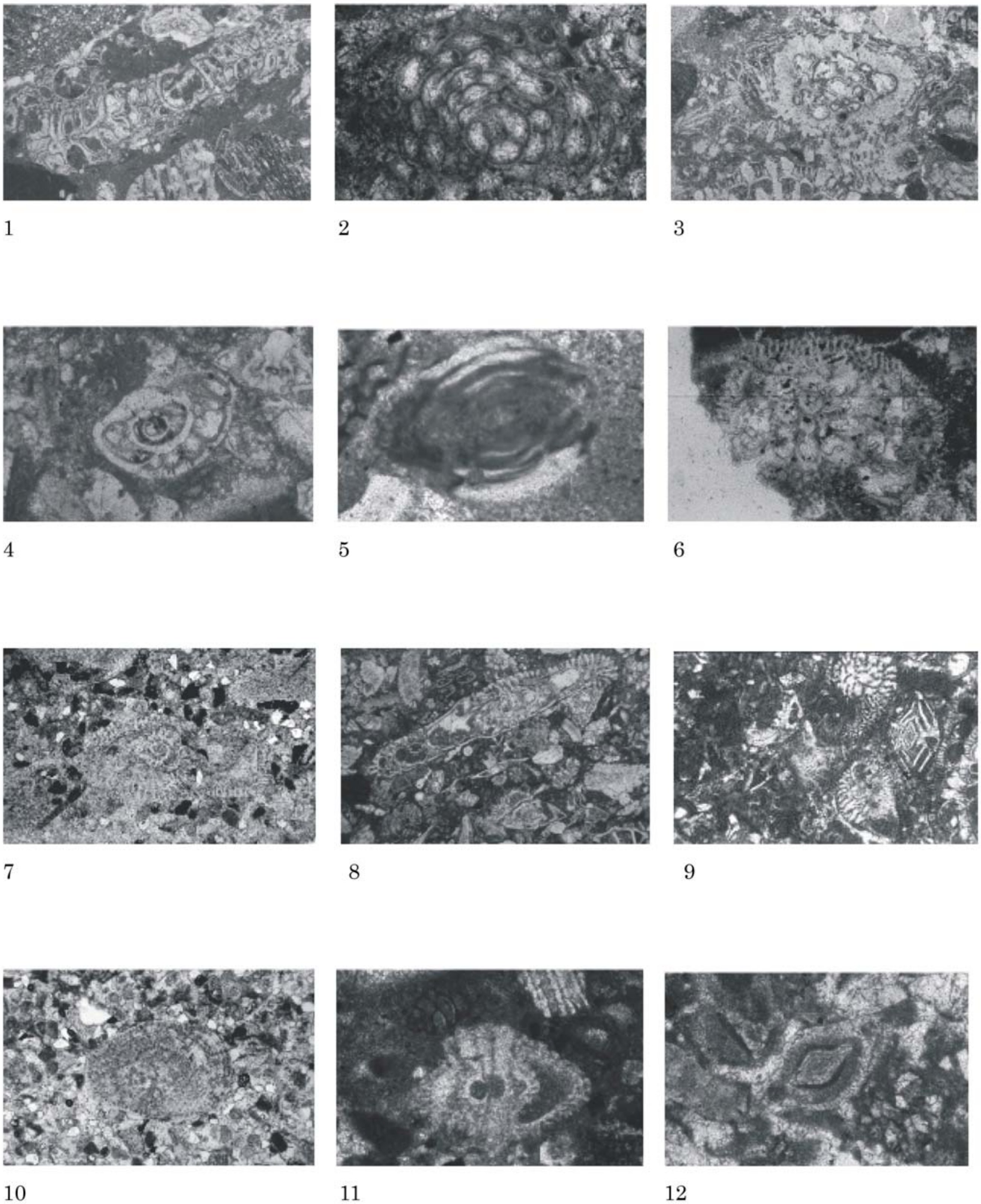
8 Vertical section of microspheric form. Locality: 908, Cide, Black Sea Region. ×20.

9 Oblique sections of specimen, showing ornamentation of chevronlike ridges in the periphery of test. *Globotruncanita stuartiformis* (Dalbietz) (left upper) and *Sirtina orbitoidiformis* Brönnimann and Wirz (left) can be seen. Locality: KM48, West Erif, Haymana region. ×20.

10 Oblique sections of specimen, showing ornamentation of honeycomb in the periphery. Locality: 801, Devrekâni, Black Sea region.×20.

11. *Cuvillierina sireli* Inan. Vertical section of megalospheric form. Locality: KM47, Çaldağ, Haymana region. ×60.

12. *Idalina antiqua* Munier-Chalmas and Schlumberger. Axial section of microspheric form, but outside og globular test decalcified. Locality: KM35, Çaldağ, Haymana region. ×30.


1
2
3
4
5
6
7
8
9
10
11
12

Assemblage 1 are *Lepidorbitoides pembergeri, Planorbulina cretae, Pseudorbitoides trechimanni, Simplorbites papyraceus, Sirtina orbitoidiformis, Sivasella monolateralis, Sulcoperculina dickersoni, Minouxia* spp., *Pseudolituonella* spp., *Textularia* spp. and *Pseudedomia hamaoui* (Text-figure 5B). The Campanian species *Lepidorbitoides pembergeri* and *Pseudorbitoides trechimanni* are reworked from the lower Campanian horizons due to the turbidity current. The Assemblage 1 is correlated with the upper Campanian CVIa to CVIII benthonic foraminiferal zones in the Charentes and Dordogne, France (Bignot and Neumann 1991) based on common occurrences of above seven species. Also, the Assemblage 1 may partial be correlated with the fauna in the upper Buldandere Formation (sample 734), Bolu (Sirel 1995) due to common occurrences of *Orbitoides tissoti, O. media* and *Pseudosiderolites vidali* (Text-figure 10B). Further, it can be correlated with the planktonic foraminiferal zones, Zone KS27 or *Globotruncanita calcarata* zone (Sliter 1989; Caron 1985) due to the occurrence of *Globotruncanita stuartiformis*, but not the presence of *G. calcarata* (Text-figures 6B, 11B). *Pseudorbitoides trechimanni* has been found from the Beyobasi Formation (sample KM3) (Matsumaru 1997), which is known as reworked species in the Assemblage 3. The Beyobasi Formation (samples KM3 to KM25) in the east Erif section, Haymana contains planktonic foraminiferal species of *Globotruncanita* cf. *subspinosa* as reworked species (Text-figure 6A). Also, the Çaldağ Formation (sample KM8) in the Bahaçecik section contains *Globotruncanita elevata* as reworked species (Text-figure 6B). As such, these species of *G. stuartiformis, G.* cf. *subspinosa* and *G. elevata* may sound the Zone KS27 in the lower Haymana Formation.

Geological age: Late Campanian.

**Assemblage 2: *Orbitoides tissoti – O. media – O. megaloformis – O. gruenbachensis – Omphalocyclus macroporus* (Lamarck) - *Siderolites calcitrapoides* Lamarck.**

The six defined species of the assemblage occur in a composite fauna derived from two type samples 902 and 906 of the variations in environment of the lower Hisalköy Formation in the Cide section, Black Sea region. This assemblage (Assemblage 2) is defined by the occurrence of above six defined species (Text-figure 10A). The Assemblage 2 is known from the other samples as follows: sample KM9 of the Beyobasi Formation in the east Erif section (Text-figures 3, 5A), sample N1 of the top sandstone (Unit C) of the Haymana Formation (Text-figures 4, 5A) and samples 202 to 203 of the Kakarca Formation in the Kizderbant, Yalakdere, Karamursel (section 2) (Text-figures 7, 10A) and samples 901 to 907 of the lower Hisalköy Formation (section 9) (Text-figures 7, 10A). The following species characterize this assemblage: *Anomalinoides rubiginosus, Cuvillierina soezerii, Lepidorbitoides* spp., *Mississippina binkhorsti, Planorbulinella dordoniensis, Planorbulina cretae, Pseudorbitoides trechimanni, Rotalia* spp., *Siderolites calcitrapoides, Simplorbites papyraceus, Sirtina orbitoidiformis, Sulcoperculina dickersoni, Slcorbitoides pardoi, Chrysalidina* spp., *Textularia* spp., *Pseudedomia* spp. and *Pseudolituonella* spp. (Text-figures 5A, 10A). The Unit C (sample N1) of the Haymana Formation yields the planktonic foraminifera *Heterohelix* spp. and *Globotruncanita stuartiformis*, which indicates from the top Zone KS24 to lower Zone KS31 (Sliter 1989; Caron 1985). If the Assemblage 1 is assigned to the zone KS27, the Assemblage 2 may at least be assigned to the zone KS28. Also, the Kakarca Formation (sample 201) and lower Hisarkoy Formation (samples 901 to 907) yield the planktonic foraminifera *Heterohelix* spp., *Globotruncana aegyptiaca, G.*

---

## PLATE 8

1. *Idalina antiqua* Munier-Chalmas and Schlumberger. Equatorial section of microspheric form. Locality: KM35, Çaldağ, Haymana region. ×60.

2-4. *Idalina sinjarica* Grimsdale

- 2 Subaxial section of megalospheric form, associated with *Pseudochrysalidina* spp. (left). Locality: KM24, Haymana region. ×20.
- 3 Equatorial section of microspheric form. KM26, Çaldağ, Haymana region. ×20.
- 4 Axial section of megalospheric form. Locality: KM26, Çaldağ, Haymana region. ×20.

5-6. *Pseudedomia hamaouii* Rahaghi. Locality: KM25, East Erif, Haymana region. 5. ×40, 6. ×30.

- 5 Equatorial section of megalospheric form.
- 6 Oblique section.

7. *Moncharmontia apenninica* (De Castro). Oblique section of microspheric form, associated with *Idalina sinjaric*a Grimsdale (left). Locality: KM32, Çaldağ, Haymana region. ×50.

8. *Mississippina binkhorsti* (Reuss). Axial section of microspheric form. Locality 930, Cide, Black sea region. ×60.

9-10. *Loftusia ketini* Meriç. Locality: KM34, Çaldağ, Haymana region. ×30. Scale is 1000 micron.

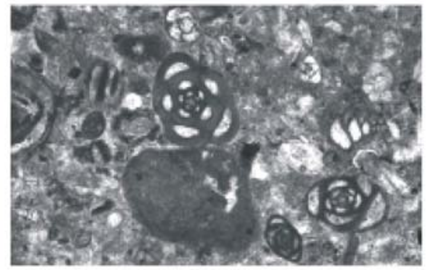
- 9 Transverse section.
- 10 Equatorial section.

11-12. *Navarella joaguini* Ciry and Rat

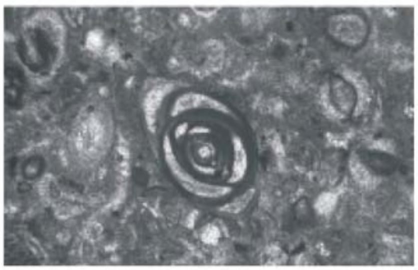
- 11 Subaxial section of specimen, associated with *Omphalocyclus macroporus* (Lamarck) (lower). Locality: 915, Cide, Black Sea region. ×10,
- 12 Axial section of megalospheric form. Locality: 1002, Kokaksu, Black Sea region. ×20.

1

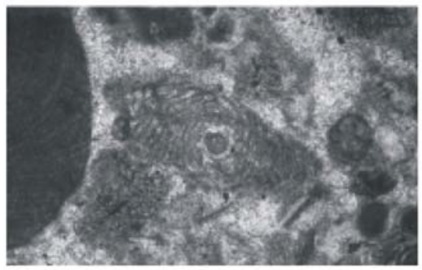
2



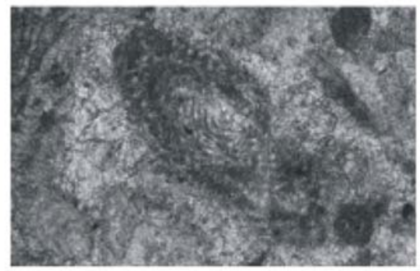
3



4



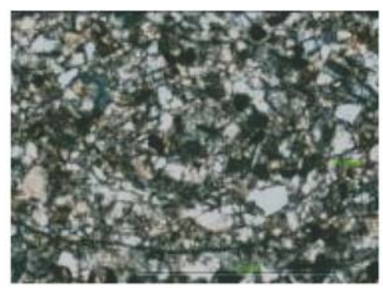
5



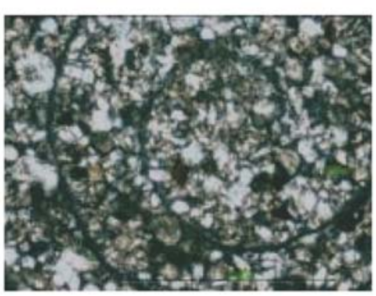
6

7

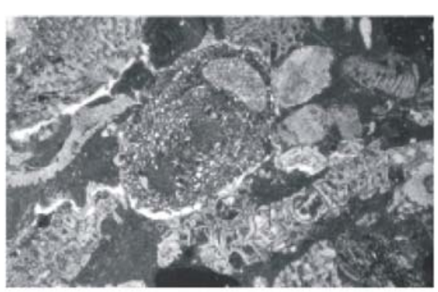
8



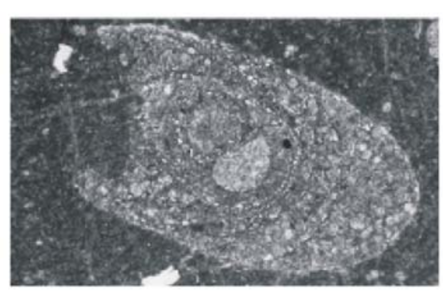
9



10



11



12

*arca, G. falsostuarti, G. lineiana, G.* spp., *Globotruncanita conica, G. stuarti, G. stuartiformis, Globotruncanella citae, Rugoglobigerina* spp., *Gansserina gansseri* and *Pseudotextularia elegans* (Text-figures 11A). They indicate the Zone KS30 or *Gansserina gansseri* zone (Sliter 1989; Caron 1985). As such, the Assemblage 2 may totally indicate the Zones KS28 to KS30.

Geological age: Early Maastrichtian.

**Assemblage 3: *Orbitoides apiculata* Schlumberger – *Omphalocyclus macroporus* – *Lepidorbitoides minor* (Schlumberger) – *L. socialis* (Leymerie) – *Siderolites calcitrapoides* - *Sirtina orbitoidiformis* Brönnimann and Wirz – *Navarella joaguini* Ciry and Rat – *Nummofallotia cretacea* (Schlumberger).**

The eight species above occur in a composite fauna derived from two type samples that represent various environmental conditions, and this assemblage is defined by the biostratigraphic occurrence of the above eight species. The first is sample KM47, Beyobasi Formation in the Çaldağ section, west Haymana, which yields *Lepidorbitoide*s *minor, L. socialis, Orbitoides apiculata, Omphalocyclus macroporus, Siderolites calcitrapoides, Sirtina orbitoidiformis* and *Navarella joaguini* (Text-fifure 5A). The second sample, KM25 of the Beyobasi Formation in the east Erif section, Haymana yields *Lepidoebitoides* spp., which seems to be *L. socialis, Orbitoides apiculata, Siderolites calcitrapoides, Sirtina orbitoidiformis,* and *Nummofallotia cretacea* (Text-figure 5A). Assemblage 3 is also known the Beyobasi Formation (samples KM34, KM35 and KM41) in the Çaldağ section (Text-figure 5A); Beyobasi Formation (samples KM3, E1044 to E1034) in the east Erif section (Text-figure 5A); and Hisalköy Formation (samples 908 to 915) in Cide (section 9) (Text-figure 10A). In addition, the Akveren Formation (samples 1220 to 1227) in Avdal, Agva (section 12) and Akveren Formation (samples 1301 and 1302) in Yeºilcay, Agva (section 13) yield *Navarella joaguini,* but other diagnostic species are obscure due to the environment of deeper facies (Text-figure 10B). The other species in the Assemblage 3 are *Anomalinoides rubiginosus, Clypeorbis mammillatus, Conorbitoides cristalensis, Cuvillierina soezerii, C.* spp., *Planorbulina cretae, Hellenocyclina beotica*, *Kathina* sp. A, *Mississippina binkhorsti, Orbitoides gruenbachensis, O. media, O. megaloformis, O. tissoti, Rotalia trochidiformis, R.* spp., *Pseudomphalocyclus blumenthali, Pseudosiderolites vidali, Simplorbites papyraceus, Sulcoperculina dickersoni, Loftusia ketini, Chrysalidina* spp., *Pseudolituonella* spp., *Textularia* spp., *Idalina antique, Keramosphaerina* spp., *Pseudedomia hamaoui, Hellicorbitoides longispiralis, Pseudorbitoides trechimanni* and *Planorbulinella dordoniensis* (Test-figures 5A, 10A). The last three species are reworked. The Hisalköy Formation (samples 908 to 915) yields the planktonic foraminifera *Heterohelix* spp., *Guembelitria cretacea, Globotruncana aegyptiaca, G. arca, G. falsostuarti, G. linneiana, G.* spp., *Globotruncanita conica, G. stuarti, G. stuartiformis*, *Globotruncanella citae, Abathomphalus mayaroensis* and *Racemiguembalina fructicosa* (Text-figure 11A). These species indicate the Zone KS31 or *Abathomphalus mayaroensis* zone (Sliter 1989; Caron 1985).

Geological age: Late Maastrichtian.

**Assemblage 4: *Orbitoides apiculata* – *Omphalocyclus macroporus* – *Lepidorbitoides socialis* – *Siderolites calcitrapoides* – *Planorbulina cretae* (Marsson) – *Sirtina orbitoidiformis* –**

## PLATE 9

1. *Hoeglundina elegans* (d'Orbigny). Centered oblique section of megalospheric form. Locality: 104, Tavşantepe, Black Sea region. ×50.

2-4. *Pseudolituonella* spp.

2 Axial section of megalospheric form, type 1, *Orbitoides* spp. can be seen. Locality: 2. KM47, Haymana region. ×50.

3 Axial section of microspheric form, type 2. Locality: KM2, Haymana region. ×20.

4(L) Centered oblique section of megalospheric form (type 2). Locality: KM2, Haymana region. ×20.

4(R) Axial section of microspheric form, type 2. Locality: KM2, Haymana region. ×20.

5. *Praechrysalidina* sp. Axial section of microspheric form. Locality: KM2, Çaldağ, Haymana region. ×50.

6. *Chrysalidina* sp. Axial section. Locality: E1032, East Erif, Haymana region. ×50.

7. *Pseudochrysalidina* sp. Axial section of microspheric form. Locality: KM46, Çaldağ, Haymana region. ×50.

8. *Sistanites iranica* Rahaghi. Centered oblique section of megalospheric form. Locality: E1031, East Erif, Haymana region. ×50.

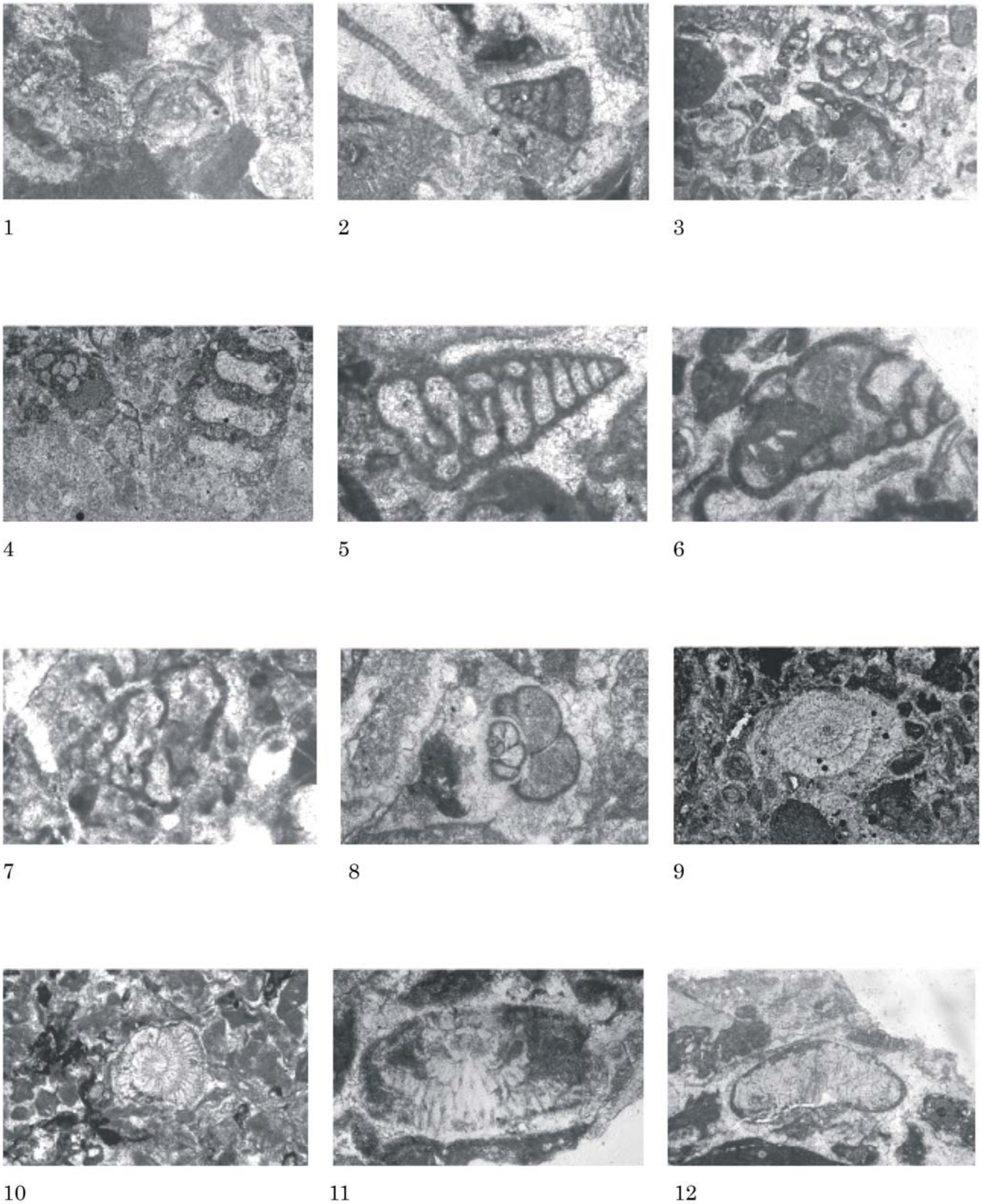
9. *Dictyokathina simplex* Smout. Centered oblique section of microspheric form. Locality: KM5, East Erif, Haymana region. ×20.

10-12. *Laffitteina bibensis* Marie

10 Tangential section. Locality: KM5, Haymana region. ×20.

11 Axial section of megalospheric form. Locality: E1033, Haymana region. ×50.

12 Transverse section. Locality: E1031, East Erif, Haymana region. ×20.


1
2
3
4
5
6
7
8
9
10
11
12

***Hellenocyclina beotica* Reichel – *Mississippina binkhorsti* (Reuss).**

The eight species of the assemblage occur in a composite fauna derived from three type samples that represent the variations in environmental conditions in different regions. The first is sample KM40 of the Beyobasdi Formation in the west Erif section, which yields *Hellenocyclina beotica, Omphalocyclus macroporus, Orbitoides apiculata*, *Siderolites calcitrapoides* and *Sirtina orbitoidiformis* (Text-figure 5A). The second sample, 921 of the Hisalköy Formation in the Cide (section 9) yields *Hellenocylina beotica, Mississippina binkhorsti, Planorbulina cretacea, Siderolites calcitrapoides* and *Sirtina orbitoidiformis* (Text-figure 10B). The third sample, 926 of the Hisalköy Formation in the Cide yields *Lepidorbitoides socialis, Omphalocyclus macroporus, Siderolites calcitrapoides* and *Sirtina orbitoidiformis* (Text-figure 10B). The Assemblage 4 is known the Beyobasi Formation (samples KM48 and KM49) in the west Erif section (Text-figures 3, 5A); Haymana Formation (samples Y2, Y1, N2 and S1) in Haymana (Text-figures 4, 5B); Akveren Formation (samples 801 to 806) in the Devrekani, Kastamonu (section 8) (Text-figures 1, 7, 10A); and Hisalköy Formation (samples 916 to 929) in Cide (section 9) (Text-figures 1, 7, 10A-10B). The other species in the Assemblage 4 are *Anomalinoides rubiginosus, Conorbitoides cristalensis, Cuvillierina soezerii, C.* spp., *Lepidorbitoides minor, L.* spp., *Orbitoides gruenbachensis, O. media, O. megaloformis, O. tissoti, Rotalia* spp., *Pseudosiderolites vidali, Simplorbites papyraceus, Sulcoperculina dickersoni, Broeckinella arabica, Loftusia* spp., *Pseudochrysalidina* spp., *Hoeglundina elegans, Keramosphaerina* spp., *Sivasella monolateralis, Chrysalidina* spp., *Loftusia ketini, Pseudolituonella* spp., *Textularia* spp., *Opthalmidium* spp., *Lenticulina* spp., *Dentalina* spp., *Scandonea samnitica* De Castro and *Pseudorbitoides trechmanni* (Text-figures 5A, 5B, 10A, 10B). The last species is reworked. The planktonic foraminifera of samples S1, 920 and 928 in the Assemblage 4 are *Heterohelix* spp., *Globotruncana esnehensis, G. falsostuarti, G. linneiana, G.* spp., *Globotruncanita stuarti, G. stuartiformis, Abathomphalus mayaroensis, Pseudotextularia elegans* and *Racemiguembelina fructicosa* (Text-figures 6B, 11A, 11B). These species indicate the Zone KS31 or *Abathomphalus mayaroensis* zone (Sliter 1989; Caron 1985). The stratigraphic horizons carrying the Assemblage 4 is correlated with the Maastrichtian Md lithostratigraphic horizons of NW Europe, due to common occurrences of *Planorbulina cretae, Hellenocyclina beotica, Siderolites calcitrapoides, Orbitoides apiculata* and *Omphalocyclus macroporus* (Bignot and Neumann 1991, table 4).

Geological age: Late Maastrichtian.

**Assemblage 5: *Planorbulina cretae – Mississippina binkhorsti - Anomalinoides rubiginosus* (Cushman) – *Hoeglundina elegans* (d'Orbigny).**

The above four species of the assemblage occur in a composite fauna derived from two type samples 930 and 931 that represent variations in the depositional environment of the Hisalköy Formation in Cide (section 9), Black Sea region (Text-figure 10B). The Assemblage 5 is defined by the biostratigraphic occurrence of the above four species, which have been known from the Maastrichtian in Turkey, and additional new species don't exist

---

**PLATE 10**

1. *Laffitteina bibensis* Marie. Axial section of microspheric form (left) and megalospheric form (right). Locality: E1031, East Erif, Haymana region. ×20.

2-3. *Anomalinoides rubiginosus* (Cushman)

2 Equatorial section of megalospheric form. Locality: 931, Black Sea region. ×50.

3 Axial section of megalospheric form. Locality: 920, Black Sea region. ×50.

4. *Kathina* sp. A. Axial section of megalospheric form, and this form is characterized by having low trocospiral coil; calcareous wall, lamellar, and finely perforate; vertical canals between umbilical pillars; and umbilical cavities, respectively. Locality: KM34, Çaldağ, Haymana region. ×30.

5-6. *Kathina selveri* Smout. Locality: 702, Siyamoğle, Black Sea region. ×50.

5 Axial section of microspheric form, associated with infant form of *Ranikothalia nuttalli* Davies (upper).

6 Tangential section.

7. *Kathina major* Smout. Tangential section. Locality: E1033.5, East Erif, Haymana region. ×50.

8-9, 10 right. *Daviesina danieli* Smout

8 Axial section of megalospheric form. Locality: 908, Cide, Black Sea region. ×50.

9 Oblique section of microspheric form. Locality: 9. KM5, Haymana region. ×50.

10(R) Transverse section. *Sulcoperculina dickersoni* (Palmer) (9 left corner). Locality: KM21, East Erif, Haymana region. ×50.

10(L) *Pseudochrysalidina* sp. Locality: KM21, East Erif, Haymana region. ×50.

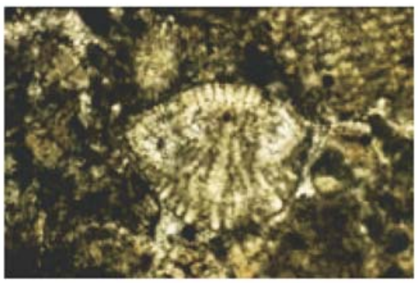
11. *Daviesina langhami* Smout. Oblique section of specimen, associated with *Minouxia* spp. (left corner) of reworked species. Locality: 1010, Kokaksu, Black Sea region. ×50.

12. *Rotalia trochidiformis* (Lamarck). Oblique section of microspheric form. Locality: 910, Cide, Black Sea region. ×50.

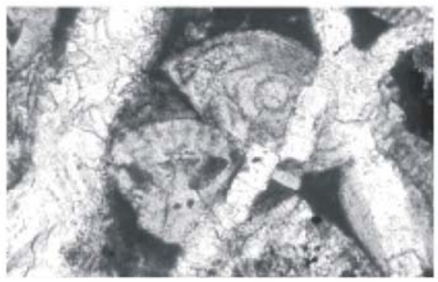
1

2

3

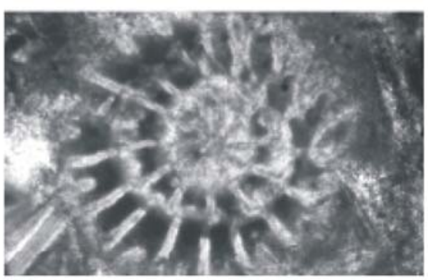


4

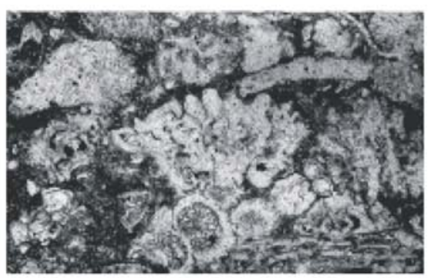


5

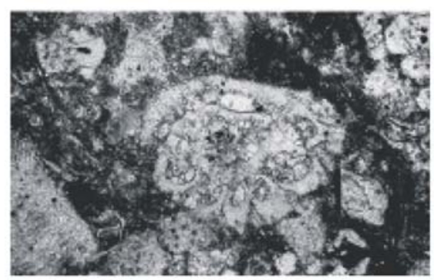
6



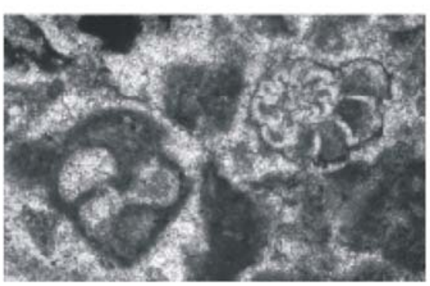
7



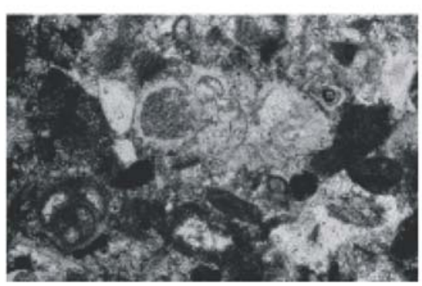
8



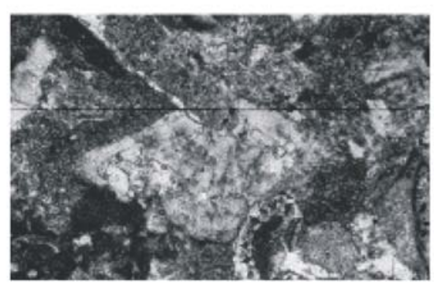
9



10



11



12

in the present assemblage. The first sample 930 yields *Mississippina binkhorsti, Planorbulina cretae* and *Hoeglundina elegans.* The second sample 931 yields *Anomalinoides rubiginosus* and *Planorbulina cretae*. The other species in the Assemblage 1 are **Cuvillierina soezerii, *C*. spp., **Lepidorbitoides* spp., **Orbitoides tissoti*, **Sirtina orbitoidiformis, Chrysalidina* spp., *Pseudolituonella* spp., *Valvulina* spp., and *Lenticulina* spp. (Text-figure 10B). Asterisk five species are reworked. The Assemblage 5 is known the Hisalköy Formation (samples 930 to 933) in the Cide section, and samples 930 to 933 stated above yield the planktonic foraminifera, *Globoconusa* ex gr. *G. daubjergensis*?, *Parvulargoglobigerina* ex gr. *P. eugubina*, *Eoglobigerina* ex gr. *E. fringa*, *Subbotina* spp., *Parasubbotina pseudobulloides, Morozovella* spp., **Globigerinelloides* spp., **Heterohelix* spp., **Contusotruncana contusa*, **Globotruncana falsostuarti, *G. linneiana, *G.* spp., **Globotruncanita stuarti, *Abathomphalus mayaroensis, *Rugoglobigerina rugosa* and **R*. spp. (Text-figure 11B). Asterisk ten species are reworked. These species indicate the Zones P0-1 (Blow 1969; Berggren and Van Couvering 1974; Smitt 1982; Toumarkine and Luterbacher 1985; Canudo et al. 1991; Berggren et al. 1995; Molina et al. 1996; Anthonissen and Ogg 2012). According to Bignot and Neumann (1991, table 4), the larger brnthonic foraminiferal fauna of *Planorbulina cretae, Rotalia trochidiformis, Fallotia* cf. *colomi* (Silvestri) and *Laffitteina mengaudi* (Astre) (= *L. bibensis*) from the Danian, NW Europe is correlated with the nannofossil zones from the Zone NP 1 to a part of Zone NP4 by Martini and Müller (1986). Drobne et al. (1988) described the fauna of *Bolkarina* sp., *Periloculina* cf. *slovenica* Drobne, *Pseudochrysalidina* sp., *Scandonea* sp., *Protoelphidium* sp., Rotaliids and miliolid-alveolinid type form from the Danian Unit 1 and Unit 2 beds (samples DV-4/5 to 24 and DV-44/8 to 38) in the Dolenja Vas section, Slovenia. Afterward, Drobne et al. (1996) described the fauna of *Protoelphidium* sp., *Pseudochrysalidina* sp. and *Scandonea* sp. from the Paleocene (Danian) limestone units in the Dolenja Vas, which was called the Shallow Benthic Zones SB1(= SBZ 1) by Serra-Kiel et al. in press. On that occasion, they neglected *Bolkarina* sp. (Drobne et al. 1988, p.157, pl. 25, figs. 1-2) from samples DV-5/4647 and DV5/6964, which should naturally be included into the SB1 zone (Serra-Kiel et al. 1998). *Bolkarina* sp. is known to be a junior synonym of *Orbitosiphon tibetica* (Douvillé) from Meghalaya, NE India (Matsumaru and Sarma 2010, p. 551), and *O. tibetica* is well known to occur the Selandian-Thanetian Lakadong Limestone, Meghalaya, and Tertiary a1 of Letter Stages, correlated with the Zones P4 to P5 of planktonic foraminiferal zones in the Philippines (Matsumaru 2011, text-figure 3). Also, Drobne et al. (1996) described carbon and oxygen isotope data and high value of Hg content in addition to Chrons Ch29R for the entire carbonate sequence of the K-T boundary layers at the Dolenja Vas. However, they (Drobne et al. 1996, p. 174) couldn't show the enrichment data of iridium in the K-T layers (breccia interval), although they described enrichment of Ir. Serra-Kiel et al. (1998) described 20 Shallow Benthic Zones (SBZ) for the Paleogene based on the compiled stratigraphic

---

**PLATE 11**

1-2. *Miscellanea globularis* Rahaghi

1 Equatorial sections of megalospheric form. Locality: KM10, Çaldağ, Haymana region. ×40. Scale is 1000 micron.

2 Axial section of megalospheric form. Locality: KM13, Çayraz, Haymana region. ×40. Scale is 1000 micron.

3-4. *Miscellanea primitiva* Rahaghi. Locality: KM17, Çaldağ, Haymana region.

3 Axial section of megalospheric form, ×60.

4 Equatorial section of microspheric form, associated with *Pseudochrysalidina* spp. (left). ×50.

5. *Pseudolacazina donatae* (Drobne). Axial section of megalospheric form (left), and equatorial section of megalospheric form (right), associated with *Miscellanea globularis* Rahaghi (right corner). Locality: KM10, Çaldağ, Haymana region. ×20.

6-7. *Peneroplis* spp. Locality: KM10, Çaldağ, Haymana region. ×20.

6 Equatorial section of microspheric form, associated with *Pseudolacazina donatae* (Drobne) (upper, lower and right) and *Idalina sinjarica* Grimsdale (left corner, left and right lower).

7 Transverse section of specimen, associated with *Orbitosiphon tibetica* (Douvillé) (right).

8. *Orbitosiphon tibetica* (Douvillé). Equatorial section of microspheric form. Locality: KM10, Çaldağ, Haymana region. ×50.

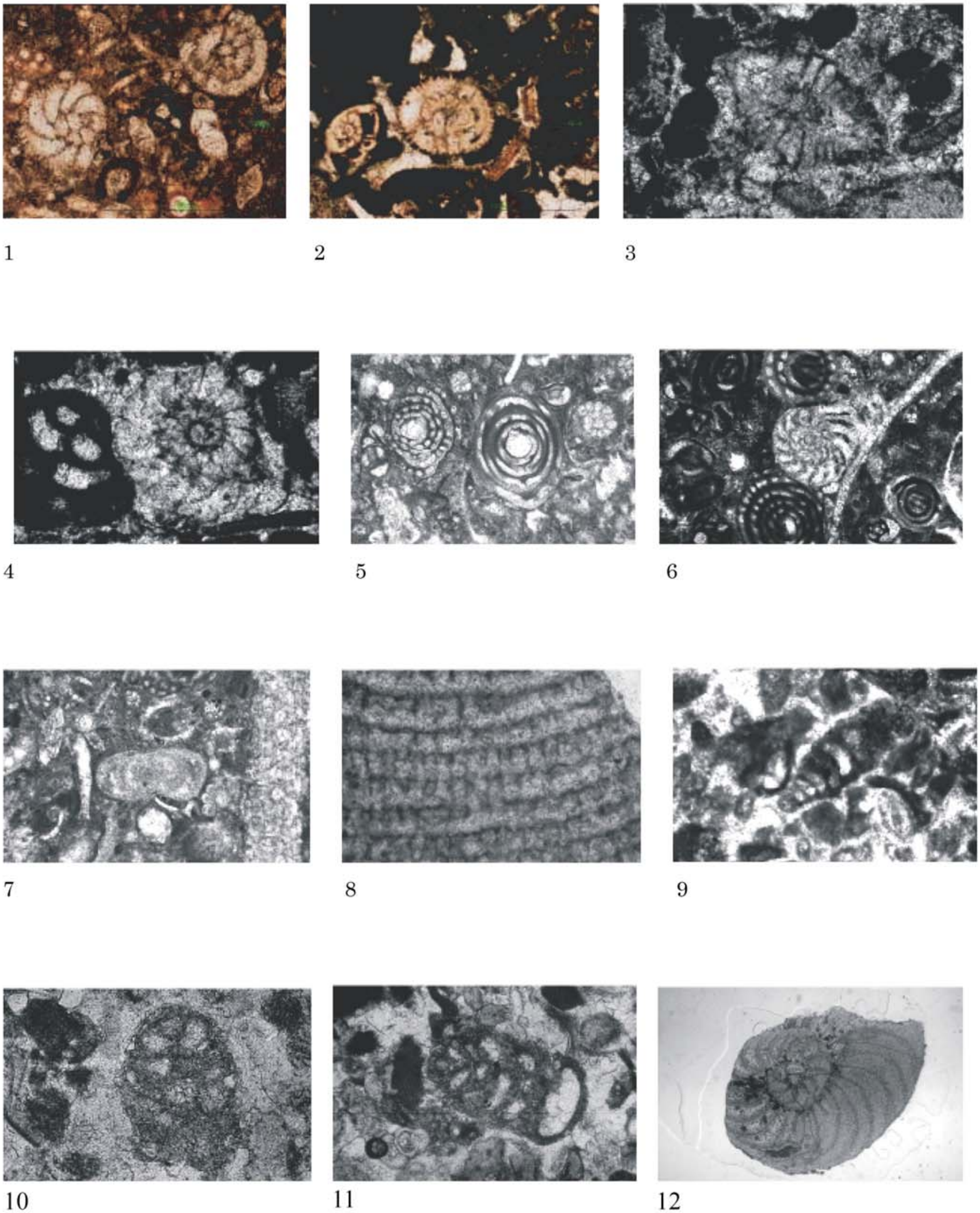
9. *Rhapydionina liburnica* Stache. Axial section of megalospheric form. Locality: KM32, Çaldağ, Haymana region. ×50.

10-11. *Coskinon rajkae* Hottinger and Drobne

10 Oblique section of specimen, showing coiled apex. Locality: 1008, Black Sea region. ×100.

11 Subaxial section. Locality: 1012, Kokaksu, Black Sea region. ×50.

12. *Operculina heberti* Munier-Chalmas. Equatorial section of megalospheric form. Loc. 921013-1, Polatli, Haymana region. ×10.


1
2
3
4
5
6
7
8
9
10
11
12

distribution of larger foraminiferal taxa. The SBZ1 (Danian) is defined by two taxa of *Laffitteina bibensis* and *Bangiana hanseni*, which is Drobne et al.'s *Protoelphidium* sp., based on reference sections and key-localities from northern Spain (Campo, Lizarraga); southern France (Belbeze); Slovenia (Dolenja Vas); and Turkey (Çaldað, Erif, Bahcecik, Dundarli, and Gölköy). Fleury et al. (1985) described the genus *Laffitteina* to be the Maastrichtian. As results of this study, the Assemblage 5 may partial be correlated with the Danian larger foraminiferal fauna of NW Europe (Bignot and Neumann 1991), although *Laffitteina bibensis* occurred the beds above the K-T boundary layers in Turkey (Text-figure 13).

Geological age: Early Paleocene (Danian).

**Assemblage 6: *Laffitteina bibensis* Marie – *Miscellanea globularis - Sistanites iranica* Rahaghi – *Idalina sinjarica* Grimsdale - *Mississippina binkhorsti* – *Scandonea samnitica.*De Castro**

The above six species of the assemblage occur in a fauna derived from the type sample (KM5) of the Çaldağ Formation in the east Erif section, Haymana region (Text-figure 5A). This assemblage (Assemblage 6) is defined by the biostratigraphic occurrence of the above five species. The common species is *Anomalinoides rubiginosus, Cuvillierina* spp., *Daviesina danieli, D. langhami, Dictyokathina simplex, Kathina major, K. selveri, Miscellanea* spp., *Operculina heberti, Planorbulina cretae, Rotalia trochidiformis, R*. spp., Chrysalidina spp., *Pseudochrysalidina* spp., *Pseudolituonella* spp., *Textularia* spp., *Miliolina* spp., *Chrysalidina* spp., *Valvulina* spp., *Hoeglundina elegans, Lenticulina* spp., *Dentalina* spp., **Hellenocyclina beotica*, **Lepidorbitoides* spp., **Omphalocyclus macroporus, *Orbitoides apiculata, *O. gruenbachensis, *O. megaloformis, *O. tissoti, *Planorbulinella dordoniensis, *Siderolites calcitrapoides, *Simplorbites papyraceus, *Sirtina orbitoidiformis, ðSulcoperculina dickersoni, *Sulcorbitoides pardoi, *Keramosphaerina* spp., **Nummofallotia cretacea, *Opthalmidium* spp., **Moncharomontia apenninica, *Minouxia* spp., and **Pseudedomia hamaoui* (Text-figures 5A, 10A, 10B). Asterisk 19 species are reworked. The Assemblage 6 is seen in the basal Çaldağ Formation (sample KM32) in the Çaldağ section, west Haymana; basal Çaldağ Formation (samples E1033.5 to KM33; KM5, type material) in the east Erif section, NW Haymana; Yağhane Formation (samples 302 and 303) in Yaðhane, Derbent, Iznik (section 3); Yağhane Formation (samples 403 and 405) in Güneytepe, Yenisehir, Iznik (section 4); Salvipinari Formation (sample 505) in Medetli, Gölpazari (section 5); Halidiye Formation (samples 601 to 606) in Kayabogazi, Göynuk (section 6); Akveren Formation (samples 807 to 810) in Devrekani, Kastamonu (section 8); Hisalkoy Formation (samples 934 and 935) in Cide (section 9); Akveren Formation (sample 1007) in Kokaksu, Zongludak (section 10) and Akveren Formation (samples 1228 to 1235) in Avdal, Ağva (section 12). Further, the Assemblage 6 contains the planktonic foraminifera such as *Subbotina triloculinoides, Parasubbotina pseudobulloides, P. trinidadensis Paramurica* ex gr. *P. inconstans,* and *P.* ex gr. *P. uncinata* in samples E1033.5,

---

**PLATE 12**

1. *Operculina canalifera* d'Archiac. Equatorial section of megalospheric form. Locality: 921013-1, Polatli, Haymana region. ×10.

2-4. *Discocyclina seunesi* Douvillé. Locality: 921013-1, Polatli, Haymana region. ×20.

2 Equatorial section of megalospheric form, showing eulepidine-trybliolepidine embryo type. *Discocyclina varians* type nepionic–equatorial chamber growth pattern of annuli.

3 Equatorial section of megalospheric form, eulepidine embryo type. *Discocyclina varians* type nepionic–equatorial chamber growth pattern of annuli.

4 Axial section of megalospheric form.

5-6. *Discocyclina archiaci* (Schlumberger)

5 Equatorial section of megalospheric form, showing *Discocyclina archiachi* type nepionic–equatorial chamber growth pattern of annuli. Locality: 921013-1, Polatli, Haymana region. ×20

6 External view of microspheric form. and 6. KM1 (= 921011-9), Çayraz, Haymana region. ×6.

7. *Orbitoclypeus ramaraoi* (Samanta). Equatorial section of megalospheric form. Locality: 701, Siyamoğle, Black Sea region. ×50.

8. Upper right specimen: *Discocyclina trabayaensis* Neumann. Tangential section of specimen, (lower left) associated with *Orbitolites complanatus* Lamarck. Locality: KM11 (= 921011-8), Çayraz, Haymana region. ×25. Scale is 1000 micron.

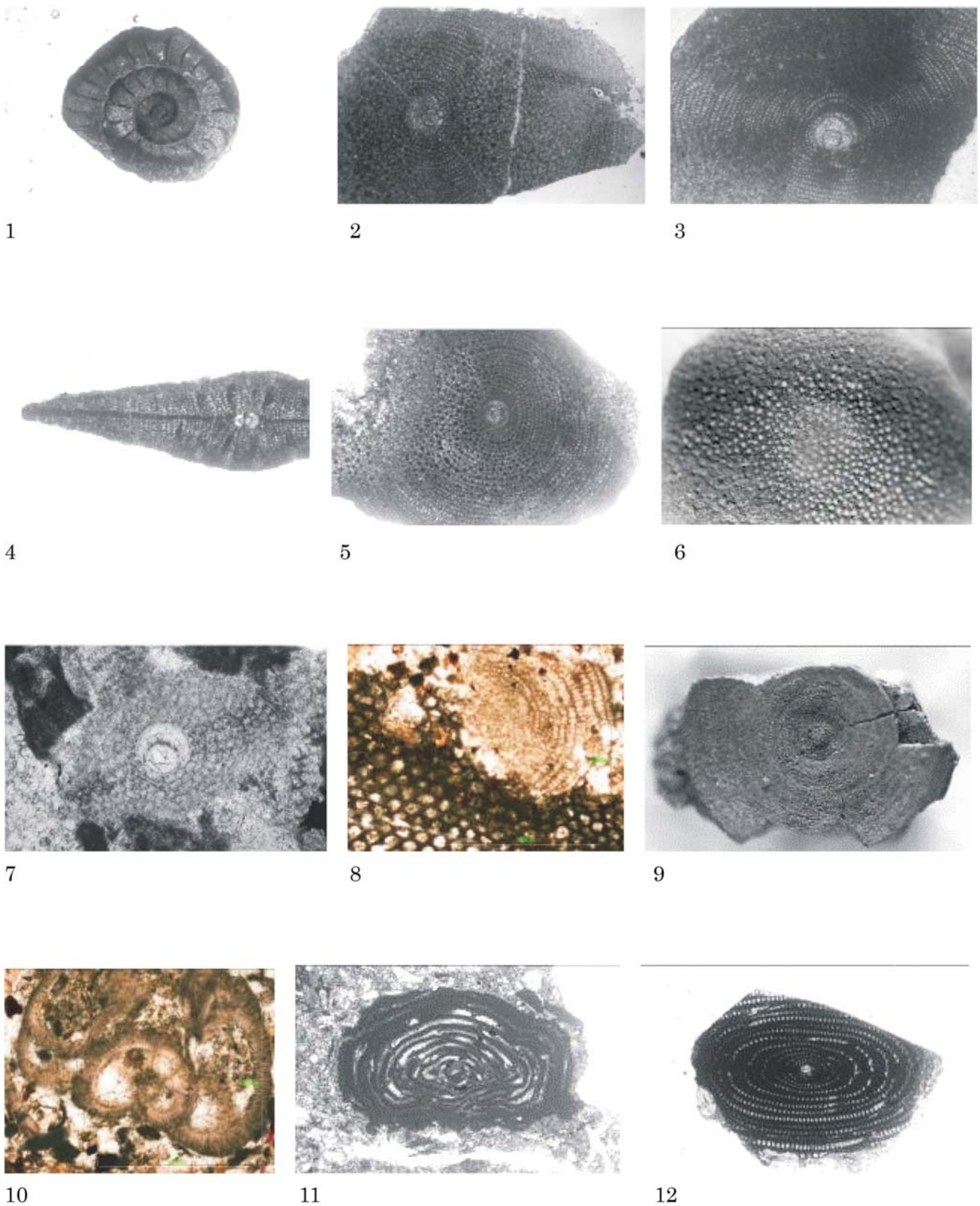
9. *Orbitolites complanatus* Lamarck. External view. Locality: KM 1 (= 921011-9), Çayraz, Haymana region. ×6.

10. *Eorupertia boninensis* (Yabe and Hanzawa). Centered oblique section of megalospheric form. Locality: KM11, Çayraz, Haymana region. ×30.

11-12. *Alveolina vredenburgi* Davies. Locality: 921013-2, Polatli, Haymana region. ×10.

11 Equatorial section of deformed megalospheric form.

12 Subaxial section of megalospheric form.


1
2
3
4
5
6
7
8
9
10
11
12

KM5, KM21, 602, 603, 604, 934, 935, 1228, 1229, 1230, 1233 and 1235 (Text-figures 6A, 11A, 11B). Then, these species indicate the Zone P2 (Blow 1969; Berggren and Van Couvering 1974; Toumarkin and Luterbacher 1985; Berggren et al. 1995).

Geological age: Early Paleocene (Danian).

**Assemblage 7: *Kathina selveri* Smout – *Daviesina danieli* Smout – *Coskinon rajkae* Hottinger and Drobne – *Idalina sinjarica* Grimsdale – *Miscellanea globularis* Rahaghi – *M. primitiva* Rahaghi – *Rotalia trochidiformis* (Lamarck).**

The seven defining species of this assemblage are found in the composite fauna of two cotype samples that represent the various environmental conditions in different areas. The first, sample 204 of the Yağhane Formation in Kizderbent, Yalakdere, Karamursel (section 2) yields *Kathina selveri, Miscellanea globularis, M. primitive*, *Idalina sinjarica* and others (Text-figure 10A). The second, sample 1010 of the Akveren Formation in Kokaksu, Zongludak (section 10) yields *Daviesina danieli, Rotalia trochidiformis*, *Coskinon rajkae* and others (Text-figure 10B). This assemblage is assigned to the Assemblage 7, and is seen in the Çaldağ Formation (samples KM2 to KM44) in the Çaldağ section; Çaldağ Formation (samples E1033 to E1031) in the east Erif section; Çaldağ Formation (samples KM31 to KM36) in the west Erif section; Çaldağ Formation (samples KM8 to KM18) in the Bahacecik section, all of the Haymana region, and Yağhane Formation (sample 204) in Kizderbent (section 2); Hisalköy Formation (samples 936 and 937) in Cide (section 9); and Akveren Formation (samples 1008 to 1014) in Kokaksu, Zongludak (section 10), all of the Black Sea region. The common species is *Anomalinoides rubiginosus, *Assailina dandotica, Daviesina langhami, Laffitteina bibensis, Miscellanea* spp., *Planorbulina create, Mississippina binkhorsti, Sistanites iranica, Rotalia* spp., *Pseudochrysalidina* spp., *Textularia* spp., *Chaldagia haymanensis*, n. gen., n. sp., *Chrysalidina* spp., *Pseudochrysalidina* spp., Pseudolituonella spp., *Textularia* spp., *Valvulina* spp., *Miliolina* spp., *Hoeglundina elegans, Scandonea samnitica, Lenticulina* spp., *Dentalina* spp., **Lepidorbitoides* spp., **Orbitoides apiculata, *O. gruenbachensis, *O. megaloformis, *Hellenocyclina beotica, *Planorbulinella dordoniensis, *Sulcoperculina dickersoni, *Opthalmidium* spp., **Siderolites calcitrapoides, *Simplorbites papyraceus* and **Minouxia* spp. (Text-figures 5A, 5B, 10A, 10B). Asterisk species are reworked and partial transported (e.g. *A. dandotica*). Also, the Assemblage 7 contains the planktonic foraminifera such as *Subbotina triloculinoides, S.* spp., *Parasubbotina pseudobulloides, *P. trinidadensis, Globanomalina chapmani* and *G. compressa* in samples KM2, KM20, KM46, E1032, KM30, KM12, KM18, 204, 936, 1006, 1007, 1008, 1009, 1010, 1011, 1012, 1013, 1014, 1303 and 1304 (Text-figures 6A, 6B, 11A, 11B). Asterisk species is reworked. These planktonic foraminifera indicate the Zone P3 (Blow 1969; Berggren and Van Couvering 1974; Toumarkine and Luterbacher 1985; Berggren et al. 1995). Further, the Assemblage 7 is correlated with the Assemblage 1: *Broeckinella arabica* Henson – *Coskinon rajikae – Idalina sinjarica – Miscellanea primitiva – Pseudolituonella* sp. (nov.) – *Rotalia trochidiformis* of the lower Masungit Limestone, Maybangain Formation in the Pinugay Hill, Mid-Luzon; and lower limestone of the Barcelona Group, East Mindanao, Philippines, which are assigned to the Tertiary a0 in the Letter Stages, due to common occurrences of *Coskinon rajkae, Idalina sinjarica, Miscellanea primitiva* and *Rotalia trochidiformis* (Matsumaru, 2011, p. 238) (Text-figure 12).

Geological age: Middle Paleocene (Selandian).

---

**PLATE 13**

1-2. *Alveolina canavarii* Checchia-Rispoli. Locality: 921013-2, Polatli, Haymana region. ×5.

1 Equatorial section of megalospheric form.

2 Axial section of megalospheric form.

3. *Alveolina oblonga* d'Orbigny. Axial section. Locality: 921011-10, Çayraz, Haymana region. ×5.

4. *Lockhartia conditi* (Nuttall). Axial section of microspheric form. Locality: KM29, Çayraz, Haymana region. ×30. Scale is 1000 micron.

5. *Lockhartia haimei* (Davies). Axial section of megalospheric form. Locality: KM29, Çayraz, Haimana region. ×40. Scale is 1000 micron.

6-7. *Nummulites deserti* de la Harpe. Locality: 921011-4, Çayraz, Haymana region. ×6.

6 External view of microspheric form.

7 Internal view of microspheric form.

8-9. *Nummulites globulus* Leymerie. Scale is 1000 micron.

8 External view. Locality: KM23, Çayraz, Haymana region. ×5.

9 Equatorial section of megalospheric form. Locality: KM11, Çayraz, Haymana region. ×30.

10-11. *Nummulites atacicus* Leymerie. Locality: KM42 (= 921011-5b), Çayraz, Haymana region. ×5.

10 External view of microspheric form.

11 Internal form of microspheric form.

12. *Nummulites irregularis* Deshayes. Equatorial section of microspheric form. Locality: 921011-10, Çayraz, Haymana region. ×25. Scale is 1000 micron.

1

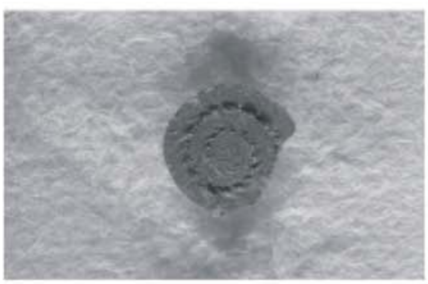
2

3

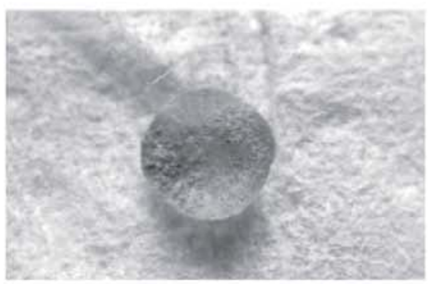
4

5

6



7



8

9

10

11

12

**Assemblage 8: *Kathina selveri – K. major* Smout - *Discocyclina seunesi* Douvillé – *Miscellanea globularis – M. primitiva – Ranikothalia nuttalli* (Davies) – *Pseudolacazina donatae* (Drobne).**

The seven species defining of this assemblage are found in the composite fauna of three co-type samples that represent the variations in environmental conditions in different regions. The first, sample KM26 of the Ilginlikdere Formation in the Çaldağ section, west Haymana yields *Miscellanea globularis, M. primitiva*, *Pseudolacazina donatae* and others (Text-figure 5A). The second sample, KM13 of the Yesilyurt Formation in Çayraz section, north Haymana yields *Kathina major, K. selveri, Miscellanea globularis*, *M. primitiva* and others (Text-figure 5B). The third sample, 702 of the Akveren Formation in Siyamoglu, Mengen (section 7) yields *Discocyclina seunesi, Miscellanea primitiva*, *Ranikothalia nuttalli* and others (Text-figure 10A). The assemblage is assigned to the Assemblage 8. In addition to the above type samples, the Assemblage 8 is known the Ilginlikdere Formation (samples KM24 to KM17) in the Çaldağ section; Ilginlikdere Formation (sample 921013-1) in the Polatli (Kirkkavak) section, western Haymana; Yesilyurt Formation (samples KM19 and KM13) in Çayraz section; Yağhane Formation (samples 101 to 104) in Tavşantepe, Gebze (section 1); Halidiye Formation (samples 607 and 608) in Kayabogazi, Göynuk (section 6); Akveren Formation (samples 701 and 702) in Siyamoglu, Mengen (section 7); Hisalköy Formation (samples 938 to 921915) in Cide (section 9); and Akveren Formation (samples 1015 and 1016) in Kokaksu, Zongludak (section 10). From these samples, they include the following species in the Assemblage 8: *Anomalinoides rubiginosus, Asterocyclina stella, A.* spp., *Coskinon rajkae, Dictyokathina simplex, Discocyclina archiaci* (Schlumberger), *D.* spp., *Orbitoclypeus ramaraoi, Planorbulina cretae, Kathina selveri, K.* spp., *Miscellanea* spp., *Mississippina binkhorsti, Orbitosiphon tibetica, Rotalia trochidiformis, Sistanites iranica, Chrysalidina* spp., *Pseudochrysalidina* spp., *Pseudolituonella* spp., *Valvulina* spp., *Hoeglundina elegans, Textularia* spp., *Valvulina* spp., *Idalina sinjarica, Rotalia trochidiformis, R*. spp., *Miliolina* spp., *Lenticulina* spp., *Peneroplis* spp., *Scandonea samnitica, *Sirtina orbitoidiformis, *Sivasella monolateralis, *Sulcoperculina dickersoni* and **Opthalmidium* spp. (Text-figures 5A, 5B, 10A, 10B). Asterisk species are reworked. In addition, the Assemblage 8 contains the planktonic foraminifera such as *Morozovella angulata, M. aequa, M. velascoensis, Acarinina mckannai, Globanomalina chapmani, G. compressa, G. pseudomenardii* and *Igorina pusilla* in samples KM4, KM10 and KM26 of the Ilginlikdere Formation; samples KM19, KM27 and KM13 of the Yesilyurt Formation; samples 101 and 102 of the Yaghane Formation; samples 938, 939 and 921015 of the Hisalköy Formation; and samples 1015 and 1016 of the Akveren Formation. These species partially indicate Zone P4 (Blow 1969: Berggren and Van Couvering 1974; Toumarkine and Luterbacher 1985; Berggren et al. 1995).

The Assembalge 8 is correlated with both the *Idalina sinjarica – Miscellanea primitiva – M. miscella – Kathina selveri - Lockhartia diversa Smout* Assemblage (Assemblage 1) and *Aberisphaera gambanica* Wan – *Daviesina khatiyahi* Smout – *Lochartia haimei* (Davies) – *Miscellanea miscella – Ranikothalia nuttalli* Assemblage (Assemblage 2) in the middle Paleocene (Selandian) to late Paleocene (Thanetian) Lakadong Limestone, Meghalaya, NE India (Matsumaru and Sarma 2010) (Text-figure 12). Also, the Assemblage 8 is correlated with the *Daviesina danieli – Kathina selveri – Orbitoclypeus ramaraoi – Lockhartia haimei – Miscellanea miscella – Ranikothalia nuttalli – Alveolina vredenburgi* Davies Assemblage (Assemblage 2) of the middle Paleocene (Selandian) - late Paleocene (Thanetian) lower Masungit Limestone, Maybangain Formation, Luzon Island; lower Sula Formation, Cagraray Island; and Talutunan-Tumicob Formation, Marinduque Island, all of the

---

**PLATE 14**

1-2. *Nummulites partschi* de la Harpe..
 1 External view. Locality: KM1, Çayraz, Haymana region, ×5.
 2 Internal view. Locality: KM29, Çayraz, Haymana region, ×5.

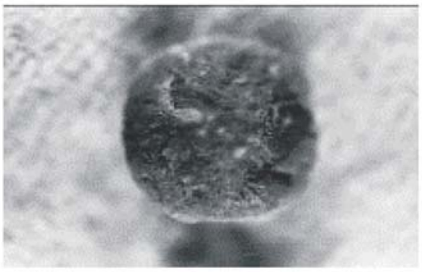
3. *Nummulites planulatus* (Lamarck). External view. Locality: 921011-14, Çayraz, Haymana region. ×5.

4-5. *Nummulites distans* Deshayes. Locality: KM11, Çayraz, Haymana region.
 4 Internal view of megalospheric form, ×6.
 5 Internal view of microspheric form, ×5.

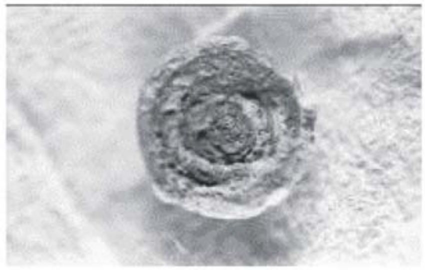
6-8. *Nummulites laevigatus* (Bruguiere). Scale is 1000 micron.
 6 External view. Locality: 921011-14, Çayraz, Haymana region. ×1.
 7 Equatorial section of microspheric form. Locality: 921011-10, KM11, Çayraz, Haymana region. ×30.
 8 Equatorial section of megalospheric form. Locality: KM11, Haymana region. ×30.

9-10. *Nummulites lehneri* Schaub. Scale is 1000 micron.
 9 Equatorial section of megalospheric form. Locality: KM11, Çayraz, Haymana region. ×30.
 10 Equatorial section of microspheric form. Locality: KM1, Çayraz, Haymana region. ×30.

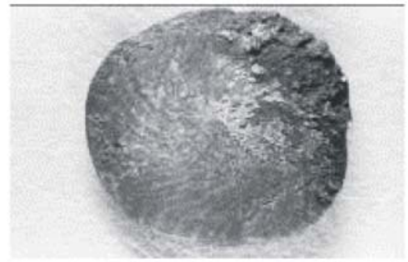
11-12. *Assilina dandotica* Davies. Scale is 1000 micron.
 11 External view. Locality: KM23 (= 921011-5a), Çayraz, Haymana region. ×5.
 12 Axial section. Locality: KM23 (= 921011-5a), Çayraz, Haymana region. ×30.



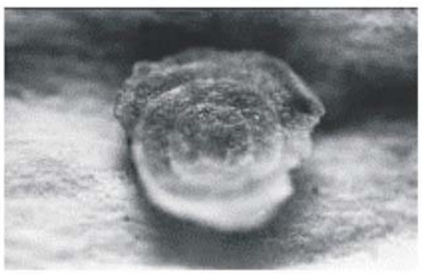
1



2

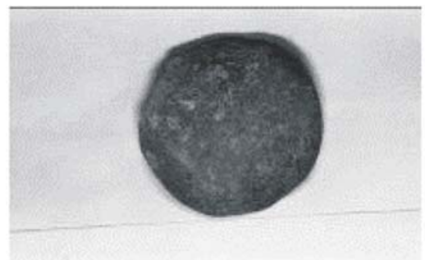


3

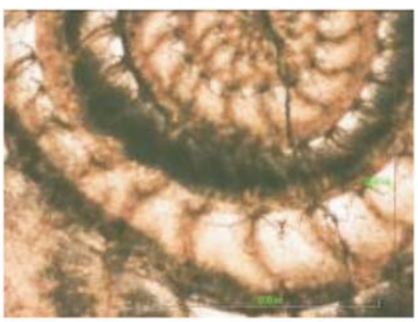


4

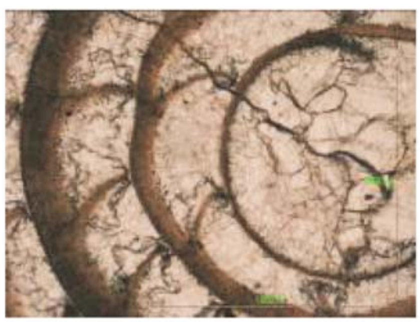
5



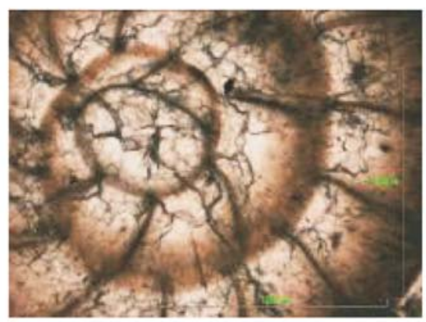
6



7



8



9

10

11

12

Tertiary a1 of the Letter Stages in the Philippines (Matsumaru 2011) (Text-figure 12).

Geological age: Middle Paleocene (Selandian) – Late Paleocene (Thanetian).

**Assemblage 9: *Assilina leymerie* d'Archiac and Haime – *A. placentula* (Deshayes) – *A. pustulosa* Doncieux – *Nummulites atacicus* Leymerie – *N. deserti* de la Harpe – *N. globulus* Leymerie – *Alveolina canavarii* Checchia-Rispoli –*A. oblonga* d'Orbigny – *Orbitolites complanatus* Lamarck.**

The nine defining species of this assemblage occur in a composite fauna derived from three type samples (KM23, KM42 and KM29) of the Ilginlikudere Formation in the Çayraz section, north Haymamna. The first sample KM23 yields *Assilina dandotica, A. leymerie, A. placentula, A. pustulosa, Nummulites deserti*, *N. globulus* and *Operculina canalifera* d'Archiac Text-figure 5B). The seond sample KM42 yields *Assilina pustulosa, Nummulites atacicus*, *N. deserti* and *Operculina canalifera* (Text-figure 5B). The third sample KM29 yields *Assilina leymerie, A. placentula,* **Daviesina danieli, Discocyclina archiaci, D*. spp., **Lockhartia conditi, *L. haimei*, *Nummulites atacicus, N. globulus, N. irregularis* Deshayes, *N. partschi* de la Harpe, *Operculina canalifera, Alveolina canavarii*, *A. oblonga, A. spp.,* and *Orbitolites complanata* (Text-figure 5B). Asterisk species are reworked. The present assemblage is assigned to the Assemblage 9, and is also known the Eskipolatli Formation (sample 921013-2) in the Polatli (Kirkkavak) section, western Haymana, and Ilginlikudere Formation (samples 921011-4 and 921011-7) in the Çayraz section. The other species in the Assemblage 9 is *Alveolina vredenburgi* Davies (Text-figure 5A). Samples KM23 yields planktonic foraminifera such as *Acarinina* spp. and *Subbotina* spp. (Text-figure 6B), but is obscure for planktonic foraminiferal zones. The Assemblage 9 is correlated with the *Alveolina oblonga – A. schwageri* Checchia-Rispoli – *Assilina laxispira* de la Harpe – *A. placentula* Assemblage 3-1 in the lower Umlatdoh Limestone, Meghalaya, NE India (Matsumaru and Sarma 2010)(Text-figure 12). Also, the Assemblage 9 is correlated with the *Alveolina subpyrenaica* Leymerie – *Nummulites atacicus – N. burdigalensis* (de la Harpe) – *N. globulus – N. millecaput* Boubée – *Opertorbitolites douvillei* Nuttall Assemblage 3 in the upper Masungit Limestone, Maybangain Formation, Luzon, which indicative of the Tertiary a2 of the Letter Stages in the Philippines (Matsumaru 2011) (Text-figure 12).

Geological age: Early Eocene (Ypresian).

**Assemblage 10: *Assilina placentula – A. cuvillieri* Schaub - *A. tenuimarginata* Heim - *A. laxispira* de la Harpe – *Nummulites laevigatus* (Bruguiere) – *N. lehneri* Schaub.**

The above six species that define this assemblage are found in the type sample KM11 (= 921011-8) of the Çayraz Formation in the Çayraz section, north Haymana. The present assemblage is assigned to the Assemblage 10, and is also known the Çayraz Formation (samples KM11 to 921011-12) in the Çayraz section (Text-figure 3). The other species in the Assemblage 10 are **Assilina exponens Sowerby, A. medanica* Pavlovec, **A. spira* (De Roissy), *A*. spp., **Daviesina danieli*, *Discocyclina archiaci, *D. seunesi, D. trabayaensis* Neumann*, D*. spp., *Eorupertia boninensis* (Yabe and Hanzawa), **Miscellanea* spp., *Nummulites atacicus, N. distans Deshayes, N. globulus, N. irregularis, N. partchi, Alveolina canavarii, A. oblonga, A.* spp., *Orbitolites complanatus,* **Operculina canalifera*, **O. heberti* Munier-Chalmas*,* **Ranikothalia nuttali* and **Keramosphaerina* spp. (Text-figure 5B). Asterisk nine species are reworked and re-deposited as allotochtonous species. Sample 921011-11 yields *Subbotina* spp., but don't indicate the planktonic foraminiferal zones (Text-figure 6B). The Assemblage 10 is partial correlated with the *Nummulites atacicus – N. globulus* Assemblage (Assemblage 3-2) in the upper Umlatdoh Limestone and *Alveolina elliptica nuttalli – Nummulites beaumonti – N. gizehensis – N. perforatus – Orbitolites complanatus* Assemblage (Assemblage 4-1) in the lower Prang Limestone, both of Meghalaya, NE In-

---

## PLATE 15

1-3. *Assilina pustulosa* Doncieux. Locality: 921011-4, Çayraz, Haymana region. 1. ×6, 2-3. ×30. Scale is 1000 micron.

1 External view.

2 Centerd oblique section of megalospheric form.

3 Axial section of megalospheric form.

4-5. *Assilina leymeriei* d'Archiac and Haime. Locality: KM23, Çayraz, Haymana region. Scale is 1000 micron.

4 External view. ×3,

5 Axial section. ×10.

6-7. *Assilina placentula* (Deshayes). Locality: KM23, Çayraz, Haymana region. Scale is 1000 micron.

6 External view. ×3.

7 Equatorial section of microspheric form. ×30.

8-9. *Assilina laxispira* de la Harpe. Locality: 921011-12, Çayraz, Haymana region. 8. ×5, 9. ×30. Scale is 1000 micron.

8 External view.

9 Equatorial section of microspheric form.

10-12. *Assilina cuvillieri* Schaub. Locality: KM11, Çayraz, Haymana region. Scale is 1000 micron.

10 External view. ×3.

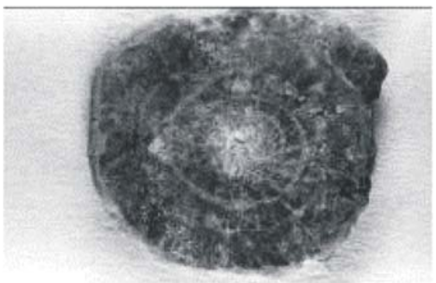
11 megalospheric form. ×30.

12 Equatorial section of microspheric form.

1

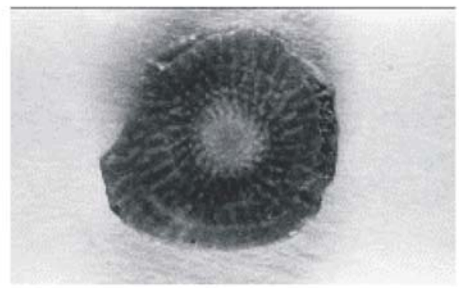
2

3

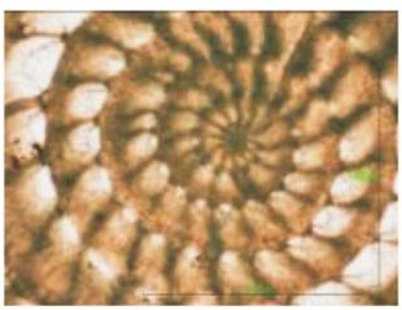


4

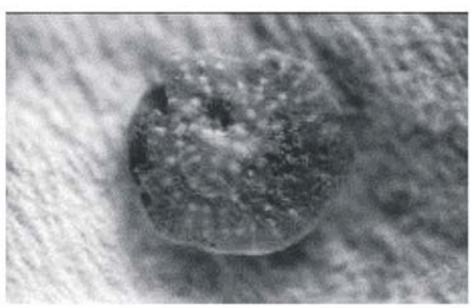
5



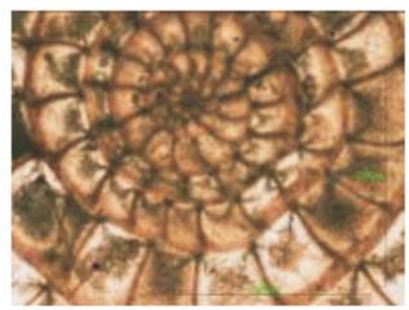
6



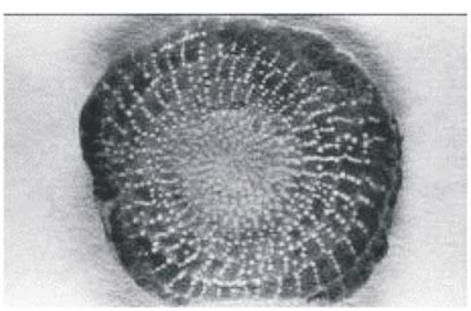
7



8

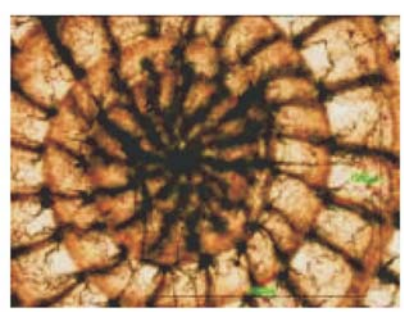


9



10

11



12

dia due to common occurrences of *Assilina laxispira, Nummulites atacicus, N. globulus, N. gizehensis* and *Orbitolites complanatus* (Matsumaru and Sarma 2010) (Text-figure 12). Also, the Assemblage 10 is partial correlated with the Assemblage 3 in the upper Masungit Limestone, Maybangain Formation, Luzon Island, that indicates the Tertiary a2 of Letter Stages in the Philippines, based on common occurrences of *Nummulites atacicus, N. globulus* and *N. distans* (Matsumaru 2011) (Text-figure 12).

Geological age: Early Eocene (Ypresian) – Middle Eocene (Lutetian).

**Assemblage 11: *Assilina exponens* (Sowerby) – *A. spira* (De Roissy).**

The above two species that define this assemblage are found together in the type sample 921011-14 of the upper Çayraz Formation in the Çayraz section, north Haymana (Text-figure 3). The present assemblage is assigned to the Assemblage 11, and is also known in sample KM43 of the upper Çayraz Formation in the Çayraz section. The occurrence species from sample KM43 is as the following: *Assilina cuvillieri, A. medanica, A. tenuimarginata, *Daviesina danieli, Discocyclina* spp., **Nummulites atacicus, *N. planulatus* (Lamarck), *Nummulites laevigatus, N. lehneri,* **Operculina heberti,* **Alveolina canavarii, Alveolina* spp., **Keramosphaerina* spp., and *Orbitolites complanatus* (Text-figure 5B). Asterisk species are reworked. Further, sample KM43 of the top Çayraz Formation in the Çayraz section, north Haymana yields the planktonic foraminifera *Acarinina* spp., but don't indicate the planktonic foraminiferal zones (Text-figure 6B). The Assemblage 11 is partial correlated with the *Nummulites acutus* (Sowerby) - *Nummulites beaumonti* d'Archiac and Haime – *N. gizehensis* (Forskal) – *N. millecaput* Boubée - *N. perforatus* (Montfort) Assemblage 4-2 in the middle Prang Formation, Meghalaya, NE India, due to common occurrences of *Orbitolites complanatus* (Matsumaru and Sarma 2010) (Text-figure 12). The Assemblage 11 is correlated with the *Nummulites gizehensis – N. perforatus – N. ptukhiani* Kacharava – *N. striatus* (Bruguiere) – *Assilina exponens* Assemblage 4 in the Formation III, Caraballo Group, Luzon Island; Taltunan-Tumicob Formation, Marinduque Island; and limestone sample 578 of the Koban Group, Mindanao Island, based on common occurrences of *Assilina exponens*. Tthe latter assemblage (Assemblage 4) is assigned to the Tertiary a3 of Letter Satges in the Philippines (Matsumaru 2011) (Text-figure 12).

Geological age: Middle Eocene (Lutetian).

**SYSTEMATIC DESCRIPTION**

Family Miliolidae Ehrenberg 1839

***Chaldagia*** Matsumaru, **n. gen.**

*Name*: This genus is named after the Çaldağ Village, Haymana Town, about 50 km SW Ankara, Turkey, where the material for study was collected.

*Type species*: *Chaldagia haymanensis* Matsumaru, n. gen., n. sp.

*Diagnosis*: Test is lituiform or French horn in outline of the megalospheric form and flabelliform in outline of microspheric form. Surface of both forms is rather smooth, but exist slightly sutural depression, and sides are flattened with blunt periphery. Megalospheric form has the embryo consisting of spherical to subspherical proloculus and second small arcuate chamber, and sometimes enrolled tube immediately following proloculus connecting second arcuate chamber in the embryo. Early stage in the megalospheric form is enrolled, more or less inclined to planispiral planes of arcuate to angular chambers, 7 chambers in a first whorl and 13 chambers in the second whorls, enlarging rapidly as added, and sutures are straight and radial in the coiling whorls and slightly depressed. Later stage is forming uncoiled and inflated or flared reniform shaped chambers as added. In the microspheric form, the early stage is strepto-

**PLATE 16**

1 *Assilina cuvillieri* Schaub. Axial section of microspheric form. Locality: KM11, Çayraz, Haymana region. ×30. Scale is 1000 micron.

2 *Assilina medanica* Pavlovec. External view. Locality: 921011-11, Çayraz, Haymana region. ×6.

3-5. *Assilina spira* (De Roissy). Locality: 921011-14, Çayraz, Haymana region. 3. ×1, 4-5. ×30. Scale is 1000 micron.

3 External view.

4 Equatorial section of megalospheric form

5 Equatorial section of microspheric form.

6-9. *Assilina tenuimarginata* Heim. Locality: KM43, Çayraz, Haymana region. 6. ×1, 7-9. ×30. Scale is 1000 micron.

6 External view.

7-8 Equatorial sections of megalospheric form.

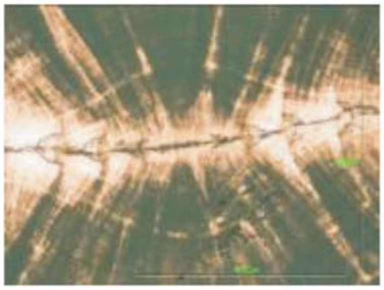
9 Axial section of megalospheric form.

10-12. *Assilina exponens* (Sowerby). Locality: KM43, Çayraz, Haymana region. 10. ×1, 11-12. ×30. Scale is 1000 micron.

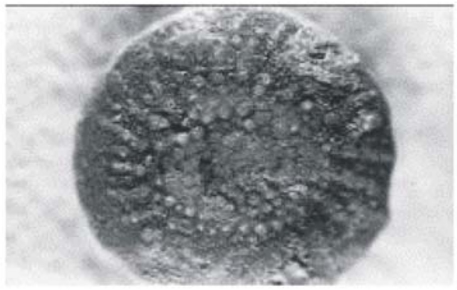
10 External view.

11 Equatorial section of microspheric form.

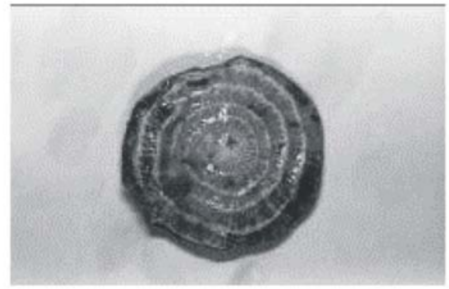
12 Transverse section.



1

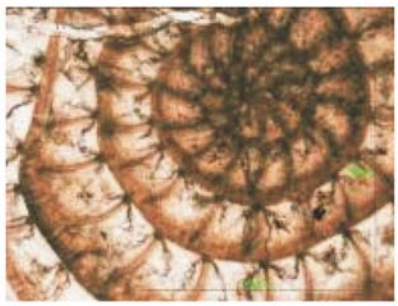


2

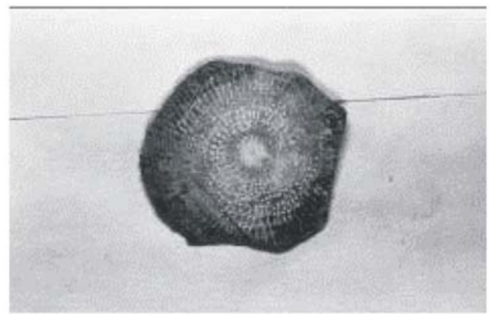


3

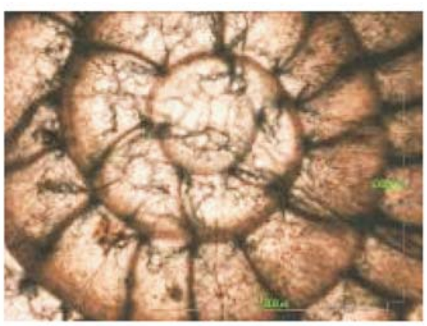
4



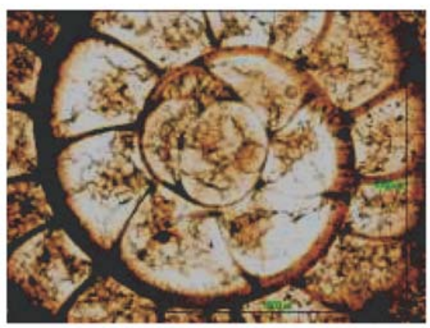
5



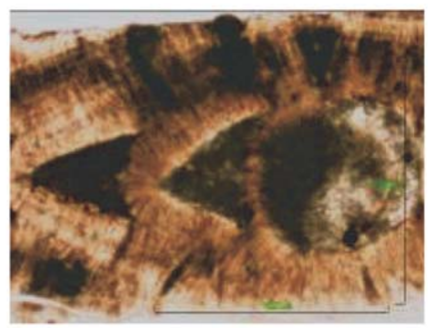
6



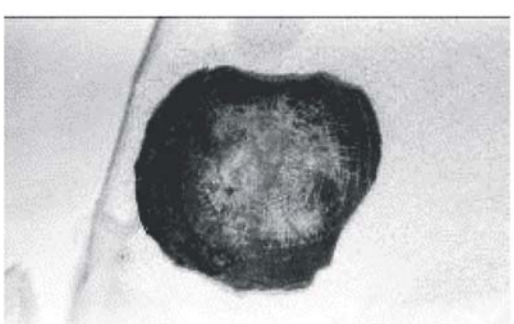
7



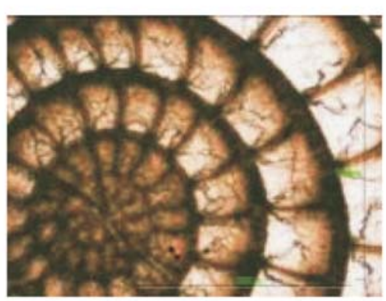
8



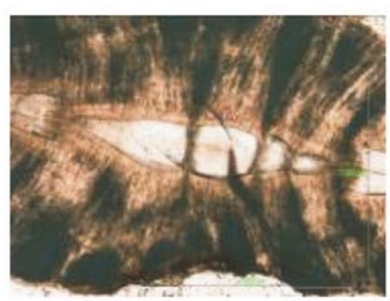
9



10



11



12

spirally enrolled of one or one-half coile(s) in length counting with total 6 or 7 chambers, which is added irregularly. After then there are enrolled planispirally of two whorls of chambers, and later stage is forming flabelliform arrangement of reniform chambers gradually inflated in tangential and radial length. The wall and septa of both megalospheric and microspheric forms are simple in structure and considerably thickened. The subepidermal partitions occur in the interior wall of chamber. The wall is calcareous, porcelaneous, imperforate and commonly including light colored calcite grains in the outer side of thick wall. The aperture consists of numerous pores as sievelike in septa of spiral chambers and terminal wall of adult chambers in rectilinear and flabelliform arrangement.

*Remarks*: *Chaldagia* resembles *Scandonea* De Castro 1971 from the upper Cretaceous of Apennines, Italy, in having spirally coiled early stage and successive uncoiled later stage and cribrate aperture. However, *Chaldagia* is different from

---

**PLATE 17**

1 *Globotruncanita elevata* (Brotzen). Axial section, showing very low trochospiral test, spiral side slightly convex, but slightly concave in the last whorl and umbilical side strongly convex with wide and deep umbilicus; a kind of carina on top of chambers except in the last chamber. Locality: KM8, Bahçecik, Haymana region. ×100.

2 Upper specimen: *Globotruncanita stuartiformis* (Dalbiez). Axial section, showing low trochospiral test, spiral side slightly convex of central part and umbilical side convex with very wide and deep umbilicus; beaded keel in periphery.

2 Lower specimen: *Contusotruncana fornicata* (Plummer). Axial section, showing low trochospiral test, biconvex, two keels present in axial periphery. Locality: 201, Kizderbent, Black Sea region. ×50.

3 *Globotruncanita* cf. *subspinosa* (Passagno). Axial section, showing very low trochospiral test, spiral side flat, but slightly convex in central part and umbilical side convex with wide and shallow umbilicus; somewhat compressed. Locality: KM8, Bahçecik, Haymana region. ×100.

4 Upper specimen: *Globotruncana linneiana* (d'Orbigny). Axial section, showing box-like shape, very low trochospiral test, spiral side almost flat to slightly convex and umbilical side almost flat with wide and shallow umbilicus; two spaced keels in periphery.

4 Lower specimen: *Globotruncanita stuarti* (De Lapparent). Axial section, showing low trochospiral test, biconvex, spiral side convex and umbilical side convex with wide and deep umbilicus; beaded keel in periphery. Locality: 907, Cide, Black Sea region. ×50.

5(L) *Globotruncanita stuarti* (De Lapparent). Axial section, the same as orientation with 4 lower.

5(R) *Contusotruncana contusa* (Cushman). Axial section, showing conical shape and high trochospiral test, spiral side strongly convex and umbilical side slightly flat with wide and deep umbilicus; narrow double keels in periphery. Locality: 921, Cide, Black Sea region. ×30.

6 *Contusotruncana fornicata* (Plummer). Axial section, the same as orientation with 2 lower. Locality: 928, Cide, Black Sea region. ×90.

7 *Globotruncana arca* (Cushman). Axial section, showing low trochospiral test, biconvex, spiral side convex and umbilical side convex with wide and fairly deep umbilicus; periumbilical rim well marked; two widely separate keels in periphery. Locality: 1001, Kokaksu, Black Sea region. ×120.

8 *Globotruncana falsostuarti* Sigal. Axial section, showing low trochospiral test, biconvex, spiral side convex and umbilical side convex with wide and fairly deep umbilicus; two narrow separate keels in periphery. Locality: 908, Cide, Black Sea region. ×100.

9 *Globotruncana aegyptiaca* Nakkady. Axial section, showing low trochospiral test, biconvex, spiral side convex and umbilical side convex with fairly wide and deep imbilicus; two narrow keels in periphery. Locality: 914, Cide, Black Sea region. ×100.

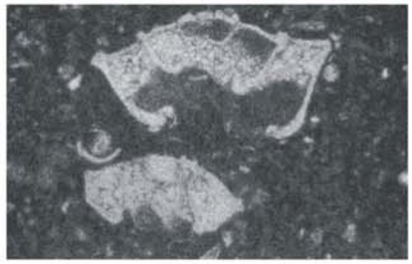
10(L) *Contusotruncana fornicata* (Plummer) Axial section, the same as orientation with 2 lower.

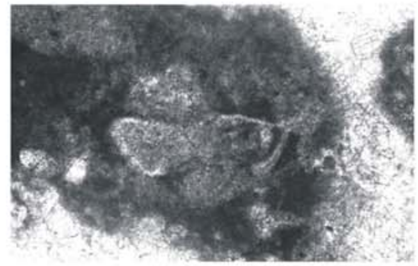
10(R) *Globotruncana arca* (Cushman). Two specimens. Axial sections, the same as orientation with 7. Locality: 1001, Kokaksu, Black Sea region. ×50.

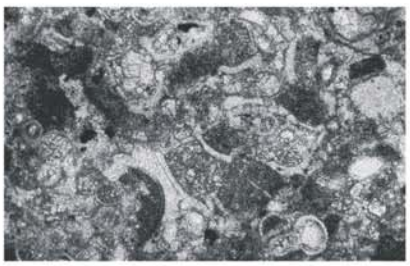
11 *Globotruncanita conica* (White). Oblique section, showing conical shape, high trochospiral test, spiral side strongly convex and umbilical side almost flat to concave with wide and deep umbilicus; one keel in perphery. Locality: 201, Kizderbent, Black Sea region. ×50.

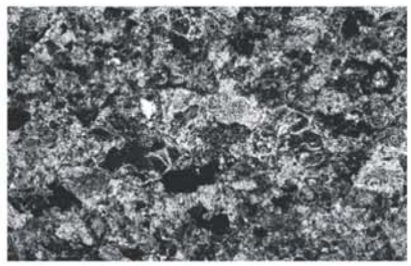
12 *Gansserina gansseri* (Bolli). Axial section,showing very low trochospiral test, spiral side flat and umbilical side strongly convex with wide and deep umbilicus; one beaded keel in periphery. Locality: 1001, Kokaksu, Black Sea region. ×100.


1

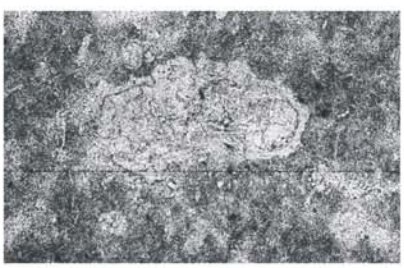

2


3

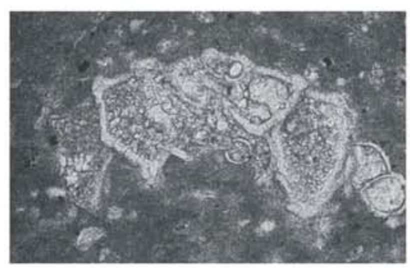

4

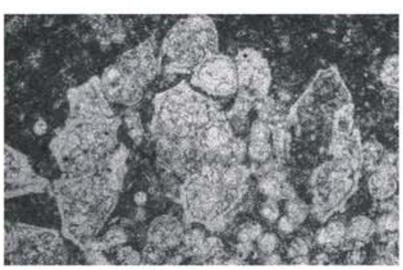

5


6


7


8


9


10


11


12

*Scandonea* in having French horn shaped megalospheric form with depressed sutures in the coiling stage, flabelliform shaped microspheric form with streptospiral coiling in the early stage, and both megalospheric and microspheric forms, always small proloculus. *Chaldagia* may resemble *Kolchidina* Morozova 1967 from the lower Paleocene (Danian) of USA and USSR (Loeblich and Tappan 1988, p. 78) in having enrolled early chambers and uncoiled later chambers, but is different from *Kolchidina* in having cribrate aperture and wall component of calcareous and porcellaneous.

***Chaldagia haymanensis*** Matsumaru, **n. gen., n. sp.**
Plate 1, figures 1-5

*Material and type specimen*: Specimens of limestone thin section KM20 in the Çaldağ Formation in the Çaldağ section, Haymana region (Text-figure 3). Holotype is megalospheric specimen in the equatorial section, Saitama University Coll. no. 201201-1 (Plate 1, figure 1). Paratype is microspheric specimen in the equatorial section, Saitama University Coll. no. 20201-2 (Plate 1, figure 2).

*Description*: Test is small and lituiform, French horn to flabelliform shaped. Megalospheric form is 0.60 to 0.96 mm in diameter and 0.58 to 0.87 mm in width in the equatorial section and probably 0.52 mm in thickness in the oblique section; and the form ratio of diameter to thickness is 1.15 to 1.84. Microspheric form is 0.80 mm in diameter and 0.75 mm in width. Spherical to subspherical proloculus and first 7 chambers in a whorl in megalospheric form are measuring internal diameter 36 × 32, 40 × 40, 56 × 64, 64 × 56, 48 × 36, 60 × 48 and 80 × 80 micron and its wall vary 8 to 12 micron thick. Enrolled tube of about a half whorl following proloculus and second arcuate chamber can be seen (Plate 1, figure 1). Spherical proloculus of

---

## PLATE 18

1 *Globotruncanita conica* (White). Axial section, the similar as orientation with figure 11 of Plate 17. Locality: 1225, Avdal, Black Sea region. ×50.

2 *Globotruncanella citae* (Bolli). Axial section, showing low trochospiral test, biconvex, spiral side convex and umbilical side convex with fairly wide and shallow; one keel in periphery. Locality: 914, Cide, Black Sea region. ×100.

3 *Abathomphalus mayaroensis* (Bolli). Axial section, showing thin box-like shape, very low trochospiral test, spiral side almost flat and umbilical side slightly flat to concave with fairly wide and shallow umbilicus; two beaded keels in periphery. Locality: 908, Cide, Black Sea region. ×50.

4 *Rugoglobigerina rugosa* (Plummer). Axial section, showing low trochospiral test, biconvex, spiral side almost flat and umbilical side convex with wide and fairly deep umbilicus; surface of chambers on periphery rugose with pustules. Locality: 1003, Kokaksu, Black Sea region. ×100.

5 *Globotruncana esnehensis* Nakkady. Axial section, showing low trochospiral test, biconvex, spiral side convex and umbilical side convex with wide and deep umbilicus; double keels in periphery. Locality: 1225, Avdal, Black Sea region. ×50.

6 *Pseudotextularia elegans* (Rzehak). Axial section, showing subtriangular shape, broader test in apertural side; chambers biserially arranged and inflated; sutures depressed and zigzag between chambers. Locality: 907, Cide, Black Sea region. ×50.

7 (L) *Racemiguembelina fructicosa* (Egger). Axial section, showing subconical test, early stage planispiral and later biserial, regularly globular chambers spread excessively forming open cone.

7 (R) *Pseudotextularia elegans* (Rzehak) Transverse section, showing inflated chambers compressed parallel to axis. Locality: 928, Cide, Black Sea rgion. ×100.

8 *Racemiguembelina fructicosa* (Egger). Axial section, the same as orientation with 7 left. Locality: 908, Cide, Black Sea region. ×80.

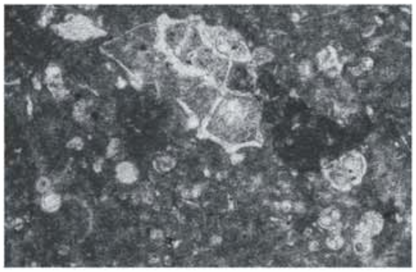
9 *Guembelitria cretacea* Cushman. Axial section, showing subconical test, globular chambers inflated, triserial throughout toward in the final stage. Locality: 1005, Kokaksu, Black Sea region. ×90.

10 *Rugoglobigerina scotti* (Brönnimann). Tangential section, showing low trochspiral; equatorial periphery lobulate; chambers tightly coiled, slightly compressed in the last chamber, and surface of chambers rugose with pustules; and imperforate peripheral band. Locality: 1003, Kokaksu, Black Sea region. x 100.

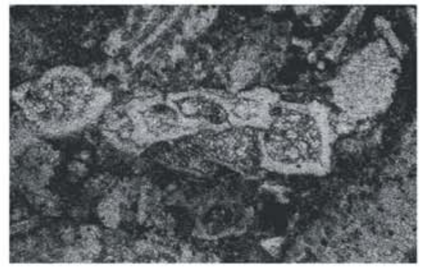
11 *Rugoglobigerina macrocephala* Brönnimann. Oblique section, showing low trochospiral; periphery lobulate; chambers increased rapidly in size and 4 inflated chambers in the last whorl, and surface of chambers rugose with pustules. Locality: 1004, Kokaksu, Black Sea region. ×100.

12 (L) *Gansserina gansseri* (Bolli). Axial section, the same as orientation with figure 12 of Plate 17.

12 (R) *Rugotruncana subpenny* (Gondolfi). Oblique section, showing low trochospiral test; last chambers slightly compressed and having more than 5; umbilicus wide and fairly deep; and periphery with double narrow keels. Locality: 1001, Kokaksu, Black Sea region. ×50.

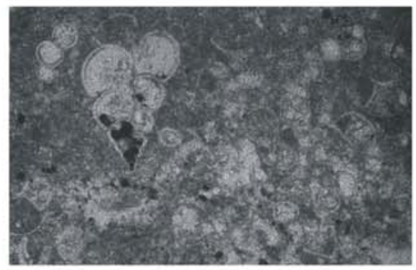

1

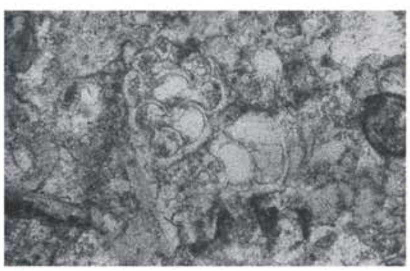

2


3

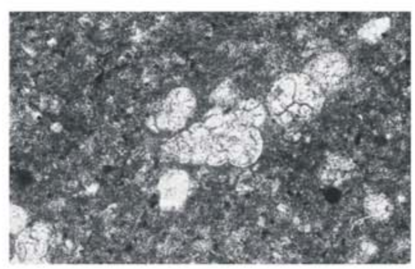

4

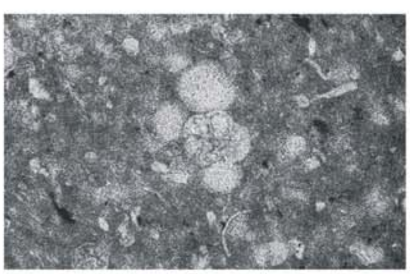

5

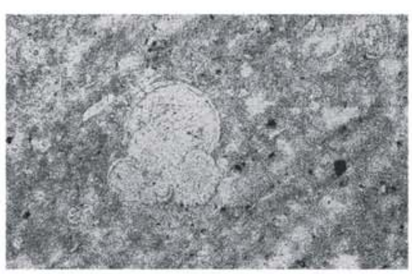

6

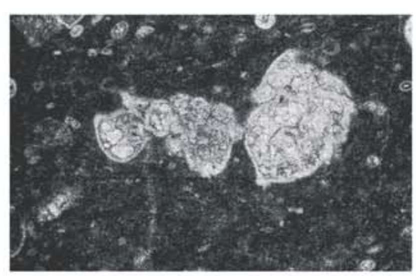

7


8


9


10


11


12

microspheric form is measuring internal diameter 18 × 18 micron and its wall 4 micron thick. Megalospheric form has planispiral coiling in the early stage and has total 2 1/2 whorls. Number of spiral chambers and distance of the first whorl are counting 7 chambers including proloculus and measuring 150 to 156, those of the second whorls, 13 chambers and 370 micron, and those of the 2 1/2 whorls, 16 chambers and 635 micronl. Microspheric form has streptospiral coiling in the early stage, and counting chambers and distance of whorl(s) are 5 or 6 chambers and 64 micron in first whorl, 11 or 12 chambers and 96 micron in the second whorls, and 16 or 17 chambers and 200 micron in the third whorl. In the later stage, there is one or two uncoiled flared chamber(s) in the megalospheric form, and probably three or four chamber layers of flabelliform arrangement in the microspheric form. Arcuate or angular shaped spiral chambers are measuring 36 × 32 to 224 × 256 micron and 12 × 8 to 200 × 136 micron in tangential and radial diameter in both megalospheric and microspheric forms. Reniform shaped uncoiled chambers in maximum sized are measuring 344 × 192 micron and 250 × 125 micron in tangential and radial diameter in both megalospheric and microspheric forms. Crebrate aperture is numerous pores of 12 to 20 micron in diameter and 8 micron in diameter in both megalospheric and microspheric forms. The wall is calcareous, porcellaneous and imperforate, measuring 32 to 56 micron thick and 30 to 38 micron thick in both megalospheric and microspheric forms.

Associated fauna: *Anomalinoides rubiginosus* (Cushman), *Miscellanea globularis* Rahaghi, *M. primitiva* Rahaghi, *Planorbulina cretae* (Marsson), **Sulcoperculina dickersoni* (Palmer), *Chrysalidina* spp., *Pseudolituonella* spp., *Textularia* spp., *Idalina sinjarica* Grimsdale, **Opthalmidium* spp., and *Scandonea samnitica* De Castro (Text-figure 5A). Asterisk species are reworked.

Stratigraphic horizon: Çaldağ Formation.

Geological age: Middle Paleocene (Selandian).

Family MILIOLIDAE Ehrenberg 1839

***Scandonea samnitica*** De Castro 1971
Plate 1, figures 6-12

*Scandonea samnitica* De Castro 1971, p. 5-6, 16-65, pl. 1, figs. 1-9; pl. 2, figs. 1-8; pl. 3, figs. 1-6; pl. 4, figs. 1-9; pl. 5, figs. 1-9; pl. 6, figs. 1-6; pl. 7, figs. 1-5; pl. pl. 8, figs. 1-7; pl. 9, figs. 1-5; pl. 10, figs. 1-5; pl. 11, figs. 1-6; pl. 12, figs. 1-8; pl. 13, figs. 1-9; figs. 1-10, 12-15, tabs. 1-6. – Bignot 1972, p. 206, 262, pl. 4, fig.4 lower (but not *Scandonea* sp.); pl.

---

## PLATE 19

1-2. *Globoconusa* ex gr. *G. daubjergensis* (Brönnimann)

1 Equatorial section. "*Subbotina*" spp. or "*Parasubbotina*" spp. (left) "*Globigerina*" spp. (right). Locality: 1013, Kokaksu, Black Sea region. ×60.

2 Oblique section showing general shape of high spiral test. and can be seen. Locality: KM19, Çayraz, Haymana region. ×90.

3. *Eoglobigerina* ex gr. *E. fringa* (Subbotina)

Equatorial section, showing trochospiral test; globular to subglobular chambers, 4 chambers in the last whorl; tightly coiled and sutures, curved. Locality: 933, Cide, Black Sea region. ×90.

4-5. *Parvulargoglobigerina* ex gr. *P. eugubina* (Luterbacher and Premoli Silva)

Equatorial sections of both forms, showing low trochospiral test; subglobular chambers, 6 chambers in the last whorl and gradually increasing in size; tightly coiled and sutures depressed. Locality: 4. 933, Cide and 5. 1229, Avdal, both of Black Sea region. ×100.

6-7. *Subbotina triloculinoides* (Plummer)

6 Slightly axial section, showing spiral side flat to slightly convex and umbilical side convex with central depression. Locality: 936, Cide, Black Sea region. ×100.

7 Tangential section, showing globular to subglobular chambers, slightly coiled and 3 1/2 chambers in the last whorl. Locality: 6. 936, Cide, Black Sea region. Locality: KM19, Çayraz, Haymana region. ×100.

8-9. *Parasubbotina pseudobulloides* (Plummer)

8 Axial section, showing low trochospiral. Locality: KM19, Çayraz, Haymana region. ×100.

9 Equatorial section, showing globular to subglobular chambers, inflated and 5 chambers in the last whorl. Locality: 1228, Avdal, Black Sea region. ×100.

10. *Parasubbotina trinidadensis* (Bolli)

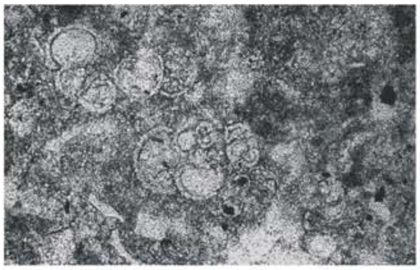
Axial section, showing very low trochospiral test, biconvex, spiral side flat or slightly convex and umbilical side convex with umbilicus fairly wide and deep. Locality: KM19, Çayraz, Haymana region. ×100.

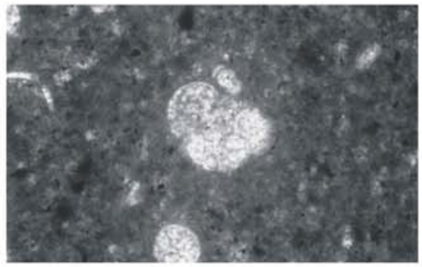
11. *Praemurica* ex gr. *P. inconstans* (Subbotina)

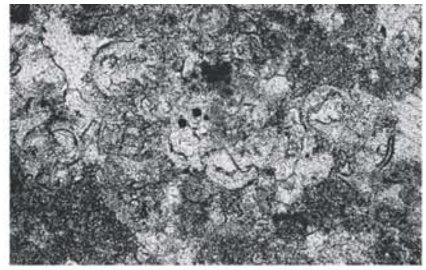
Equatorial section, showing globular to subglobular chambers, 5 chambers in the last whorl and spirals, tightly coiled. Locality: 1228, Avdal, Black Sea region. ×100.

12. *Praemurica* ex gr. *P. uncinata* (Bolli)

Subequatorial section, showing angular-conical shape of early chambers in the last whorl and later chambers subangular, sutures, strongly backwardly curved. Locality: 1228, Avdal, Black Sea region. ×100.

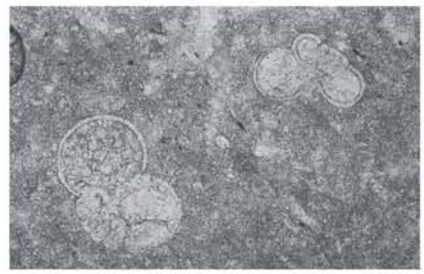

1

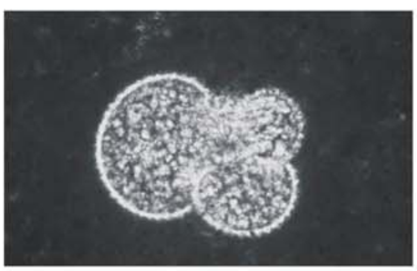

2

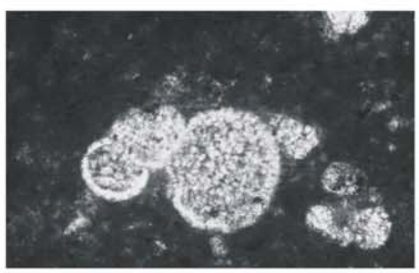

3

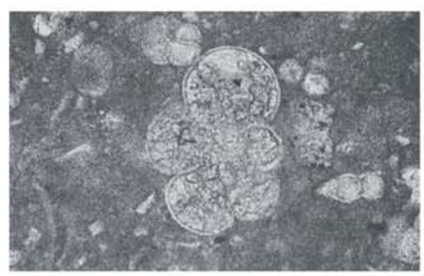

4


5

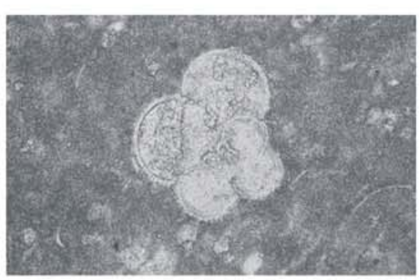

6

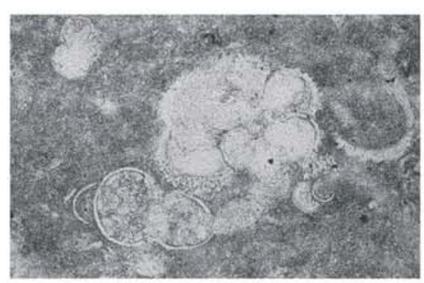

7


8


9


10


11


12

28 figs 3-4 (but not *Nodophthalmidium* sp. and *Spirolina* sp, respectively) – Meriç 1984, p. 41-43, pl. 1, figs. 1-6; pl. 2, figs. 1-6.
*Scandonea* sp. – Drobne, Ogorelec, Plenièar, Zucchi-Stolfa, and Turnšek 1988, p. 156-157, pl. 25, fig. 7.
*Haymanella paleocenica* Sirel 1999, p. 122, 124, 126, pl. 4, figs. 11-18; pl. 5, figs. 1-13.
*Kayseriella decastroi* Sirel 1999, p. 126, 128, pl. 1, figs. 1-11; pl. 2, figs. 1-12; pl. 3, figs. 1-15.

*Description*: Test is lituiform and biumbilicate to biumbonate in the coiled whorl stage and elongate and funnel in the uncoiled and rectilinear stage. Megalospheric form is measuring 0.40 to 1.20 mm in diameter and 0.40 to 0.60 mm in thickness of coiled whorls and also 1.28 to 2.30 mm in length and 0.40 to 1.15 mm in height in equatorial or longitudinal sections. Microspheric form is measuring 0.50 to 0.65 mm in diameter and 0.28 to 0.40 micron in thickness of coiled whorls and 0.75 to 2.50 mm in length and 0.28 to 0.40 mm in height in equatorial or longitudinal sections. Spherical to subspherical proloculs of three megalospheric forms are measuring inner diameter 166 × 166, 167 × 155 and 190 × 168 micron and its wall 10 to 20 micron thick. Spherical proloculus of microspheric form is measuring internal diameter of 80 × 80 micron and its wall 5 micron thick. Early stage is regularly and planispirally coiling and involute, but sometimes irregular coiling in various planes, and counting one and 1 1/2 whorl(s). Number of arcuate chambers and distance of whorl(s) in the megalospheric form are counting 5 or 6 chambers including proloculus and 345 or 356 micron in the 1/2 whorl, probably 10 chambers and 440 or 476 micron in the first whorl, and obscure and 690 micron in the 1 1/2 whorls. Those in the microspheric form are obscure, except for proloculus due to obstacle of thick spiral wall and ill preservation in the centered oblique section. Later stage is uncoiled and uniserial chambers added in a single row, and their subconical to chimney shaped chambers are gradually increased in tangential and longitudinal length. These chambers in uniserial arrangement are measuring 264 × 246 to 464 × 428 micron and 286 × 202 to 380 × 406 micron in inner tangential diameter and inner longitudinal length in both megalospheric and microspheric forms. The wall is calcareous, porcellaneous, imperforate and thick. Endoskeleton of septal wall and rudimental subepidermal partitions of inner

---

**PLATE 20**

1. *Praemurica* ex gr. *P. uncinata* (Bolli)
Axial section, showing very low trochospiral test, biconvex; spiral side flat to slightly convex and umbilical side convex with open umbilicus. Locality: 604, Kayabogazi, Black Sea region. ×90.

2. *Morozovella angulata* (White)
Axial section, showing very low trochospiral test, spiral side almost flat and umbilical side strongly convex with open umbilicus. Locality: KM19, Çayraz, Haymana region. ×100.

3-4. *Globanomalina pseudomenardii* (Bolli)
3 Equatorial section, showing trochospiral test, equatorial periphery slightly lobulate, acute with a keel. Locality: KM10, Çaldağ, Haymana region. ×50.
4 Axial section, showing very low trochospiral test, compressed; and umbilicus narrow and fairly shallow.Locality: 939, Cide, Black Sea region. ×100.

5. *Morozovella velascoensis* (Cushman)
Transverse section, showing very low trocospiral test, spiral side almost flat and umbilical side strongly convex; axial periphery with peripheral keel, and ornamented with short knobs around umbilical area of last whorl. Locality: 101, Tavşantepe, Black Sea region. ×50.

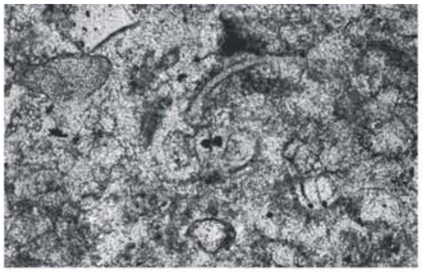
6. *Morozovella aequa* (Cushman and Renz)
Axial section, showing very low trochospiral, spiral side flat to slightly convex and umbilical side strongly convex with narrow and deep umbilicus. Locality: KM19, Çayraz, Haymana region. ×100.

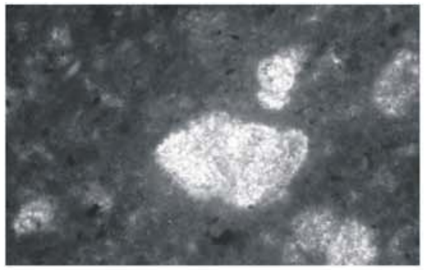
7. *Acarinina mckannai* (White)
Axial section, showing low trochospiral test, spiral side slightly convex and umbilical side strongly convex, inflated. "Subbotina" spp. (7 right) can be seen. Locality: 101, Tavşantepe, Black Sea region. ×50.

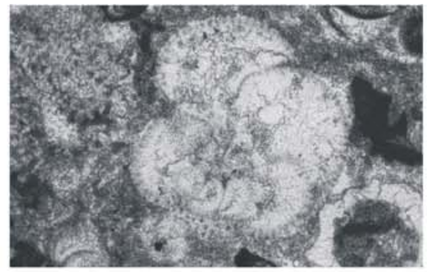
8-9. *Globanomalina compressa* (Plummer)
8 Equatorial section, showing trochospiral test, subglobular chambers, equatorial periphery lobulate, tightly coiled. Locality: 936, Cide. ×100
9 Axial section, showing very low trocospiral, inflated and somewhat compressed, and umbilicus wide and deep. Locality: 1009, Kokaksu, Black Sea region. ×96.

10-11. *Globanomalina chapmani* (Parr)
10 Equatorial section, showing trochospiral test, subglobular chambers, equatorial periphery subacute, and tightly coiled. Locality: 936, Cide. ×100
11 Axial section, showing very low biconvex, umbilical side more convex than spiral side slightly flat to convex. Locality: 1016, Kokaksu, both of Black Sea region. ×100.

12. *Igorina pusilla* (Bolli)
Axial section, showing low trocospiral test, biconvex and compressed, spiral side convex and umbilical side convex with narrow umbilicus, axial periphery acute to subacute. Locality: 1015, Kokaksu, Black Sea region. ×100.

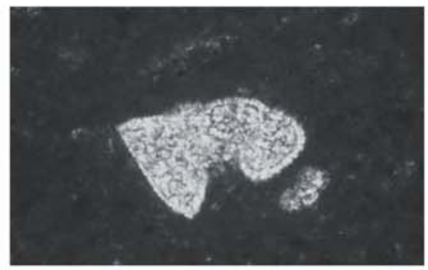

1

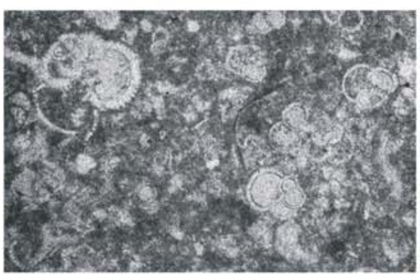

2

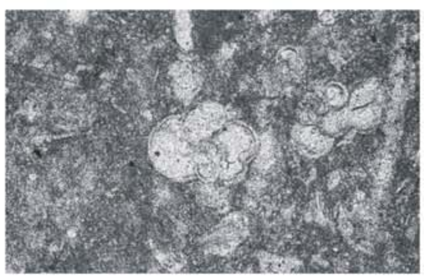

3


4


5

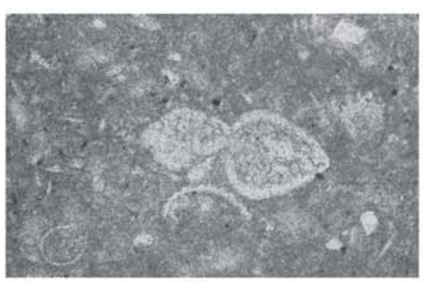

6


7


8


9


10


11


12

**PLATE 21**

Specimens of Figures 1-3, 5-6, 8-10, 13-14 and 15 are from Locality: 10. 1003, Kokaksu, Black Sea region; those of Figures 4, 7, 11-12 and 16 are from Locality: 10. 1001, Kokaksu, Black Sea region. Scale is 100 micron.

1-2. *Abathomphalus mayaroensis* (Bolli)

1a Umbilical side, showing concave; 5 chambers, angular-truncate; sutures, depressed and radial; primary apertures, interiomarginal, covered by tegilla; and periphery with double keels. ×60.

1b Spiral side, showing almost flat to slightly convex; spiral chambers, arranged about 3 whorls. ×60.

2 Lateral side, showing axial periphery, with double keels. ×70. Scale is 100 micron.

3. *Abathomphalus intermedius* (Bolli)

3a Umbilical side, showing concave; wide and inflated chambers, arranged 6 chambers in the last whorl. ×80.

3b Lateral side, showing a single keel, occurred at ventral side of spiral chambers. ×80.

3c Spiral side, showing chambers, arranged staircase-like imbricate. ×80.

4. *Contusotruncana contusa* (Cushman)

4a Umbilical side, showing concave, wide and deep umbilicus; angular chambers, arranged in flattened in the last whorl. ×50.

4b Spiral side, showing highly spiral chambers making up conic form. ×50. Scale is 100 micron.

5-6. *Globotruncanita stuarti* (de Lapparent)

5a, 6a Umbilical sides of two forms, showing umbilicus wide and deep; and trapezoidal chambers arranged 6 chambers in the last whorl, slightly overlapping along the umbilical area, and increasing in size.

5b Spiral side, showing sutures, slightly curved, raised and beaded.

6b Lateral side, showing test, low trochospiral, biconvex, and equatorial periphery, with a single keel of raised sutures. 5. ×40, 6. ×50. Scale is 100 micron.

7. *Globotruncanita stuartiformis* (Dalbiez)

7a Umbilical side, showing convex; and triangular chambers, arranged 7 chambers in the last whorl.

7b Lateral side, showing biconvex, and peripheral keel, present.

7c Spiral side, showing sutures, curved in the first whorl to straight and tangential in the last whorl. ×70.

8. *Globotruncanella citae* (Bolli)

Umbilical side, showing distinctly concave; subglobular chambers arranged 4 chambers in the last whorl, increasing in size; and peripheral keel, present. ×80.

9. *Globotruncanella petaloidea* (Gondolfi)

Umbilical side, showing concave; subglobular chambers arranged 4 chambers in the last whorl; and imperforate peripheral band, present. ×100.

10. *Globotruncana falsostuarti* Sigal

10a Umbilical side, showing umbilicus wide and fairly deep; subangular-truncate chambers arranged 7 chambers in the last whorl.

10b Oblique side, showing very low trochospiral, spiral side slightly convex and umbilical side with central depression.

10c Spiral side, showing sutures, curved, raised and beaded. ×40.

11. *Globotruncana arca* (Cushman)

11a Umbilical side, showing umbilicus, wide and fairly deep; angular-truncate chambers arranged 6 chambers in the last whorl; sutures, curved, depressed and beaded.

11b Lateral side, showing test, low trochospiral; spiral side convex and umbilical side slightly convex with central depression.

11c Spiral side, showing sutures, curved, raised and beaded. ×50. Scale is 100 micron.

12. *Rugiglobigerina rugosa* (Plummer)

12a Lateral side, showing test, low trochospiral; spiral side, fairly flat and umbilical side, wide and deep.

12b Spiral side, showing globular chambers with slightly rugose surface, 5 chambers in the last whorl, tightly coiled. ×70.

*13. Pseudotextularia elegans* (Rzehak)

Oblique side, showing subtriangular test; globular chambers biserially arranged and inflated; and sutures, zigzag between chambers. ×100.

*14. Racemiguembelina fructicosa* (Egger)

Lateral side, showing subconical test; globular chambers with costate surface, arranged biserial early stage and later becoming multiserial; and apertures, protected by ponticuli, arranged in the top side of test. ×50.

*15. Guembelitria cretacea* Cushman

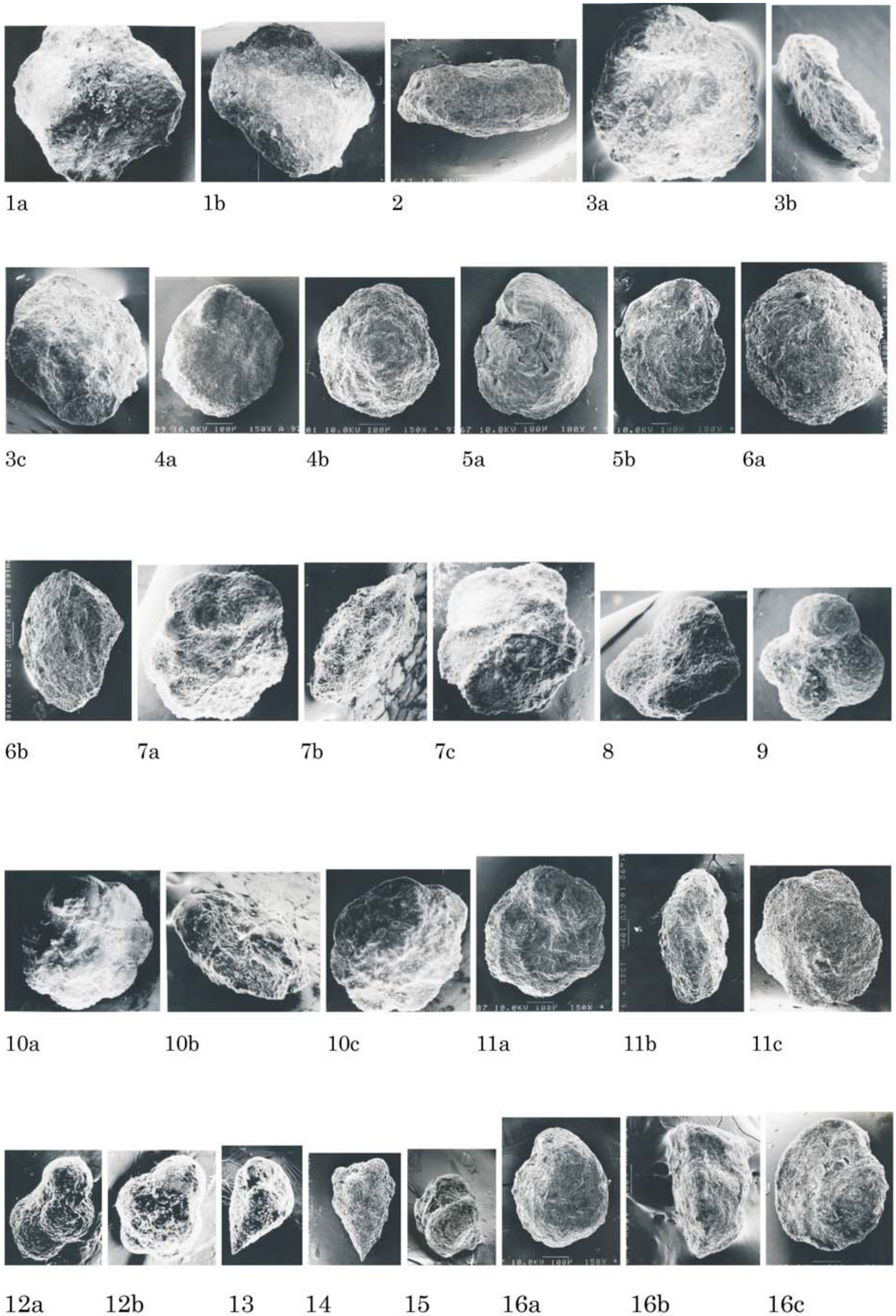
Lateral side, showing subconical test; and globular chambers with partial pore mounds, arranged triserial and infrated. ×100.

*16.Gansserina gansseri* (Bolli)

16a Umbilical side, showing test, strongly convex; hemispherical chambers, arranged 6 chambers in the last whorl.

16b lateral side, showing plano-convex test, spiral side flat and umbilical side strongly convex; a single keel, present.

16c Spiral side, showing chambers, staircase-like imbricate arrangement; sutures, curved, raised and beaded. ×50. Scale is 100 micron.


1a 1b 2 3a 3b
3c 4a 4b 5a 5b 6a
6b 7a 7b 7c 8 9
10a 10b 10c 11a 11b 11c
12a 12b 13 14 15 16a 16b 16c

uniserial chambers are developed. The aperture is numerous pores and cribrate, and measuring 22 to 48 micron in inner diameter.

*Stratigraphic horizon*: Haymana, Çaldağ, Yağhane, and Ilginlikdere Formations.

*Geological age*: Upper Cretaceous (Maastrichtian) to Middle Paleocene (Selandian).

*Remarks*: De Castro (1971) described perfectly *Scandonea samnitica*, n. gen., n. sp. from the Apennines, Italy, and this monospecies of *Scandonea* was known from the upper Cretaceous (Bignot 1972). Other authors have examined this species from the Anatoria (Haymana) in Turkey and Dinarides, eastern Adriatic coast, and this species was known until the lower Paleocene (Danian) (Meriç 1984; Drobne et al. 1988). Sirel (1999) established both genera *Haymanella paleocenica*, n. gen., n. sp. and *Kayselliella decastroi*, n. gen., n. sp. from

---

**PLATE 22**

All specimens are from Locality: 10. 1006, Kokaksu, Black Sea region. Scale is 100 micron.

1-2. *Parvulargoglobigerina eugubina* (Luterbacher and Premoli Silva)

1a, 2a Umbilical sides of both forms, showing subglobular chambers 5 chambers (1a) and 6 chambers (2a) in the last whorl; umbilicus, fairly open and shallow; and aperture, interiomarginal, and low arch. 1b, 2b. Lateral sides of both forms, showing test, very low trochospiral. and laterally compressed. 1c, 2c. Spiral sides of both forms, showing sutures, curved , slightly depressed. 1. ×200, 2. ×100. Scale is 100 micron.

3. *Eoglobigerina fringa* (Subbotina)

3a Umbilical side, showing globular to subglobular chambers, 4 chambers in the last whorl; umbilicus open and shallow; and aperture, interiomarginal and low arch.

3b Lateral side, showing test, low trochospiral; initial whorl somewhat convex and umbilical side slightly convex with central depression.

3c Spiral side, showing chambers, tightly coiled; and sutures, curved. ×200. Scale is 100 micron.

4. *Parasubbotina pseudobulloides* (Plummer)

4a Umbilical side, showing globular to subglobular chambers, inflated, 5 chambers in the last whorl; umbilicus fairly open and depressed.

4b Lateral side, showing test, low trochospiral, initial whorl somewhat flattened and umbilical side convex; and periphery rounded. 4c. Spiral side, showing sutures, curved and depressed. ×100.

5-6. *Subbotina triloculinoides* (Plummer)

5a, 6a Umbilical sides of both forms, showing inflated globular to subglobular chambers, 3 1/2 chambers in the last whorl; and periphery broadly rounded.

5b Lateral side, showing test, biconvex; spiral side initial whorl slightly convex and umbilical side, convex with central depression.

5c Spiral side, showing chambers, tightly coiled. 6b. Oblique side, showing sutures, curved and depressed. 5. ×100, 6. ×90. Scale is 100 micron.

7. *Globanomalina pentagonalis* (Morozova)

7a Umbilical side, showing subglobular chambers, 5 chambers in the last whorl; umbilicus, wide and deep; and periphery bluntly rounded.

7b Lateral side, showing test, biconvex; spiral side initial whorl convex and umbilical side convex with central depression.

7c Spiral side, showing tightly coiled. ×100. Scale is 100 micron.

8. *Globanomalina compressa* (Plummer)

8a Umbilical side, showing subglobular chambers, ovate, 5 chambers in the last whorl; umbilicus wide and open, slightly depressed.

8b Oblique side, showing very low trochospiral, and last chamber, depressed. ×80. Scale is 100 micron.

9. *Praemurica inconstans* (Subbotina)

9a Umbilical side, showing globular to subglobular chambers, 5 chambers in the last whorl; umbilicus fairly wide and depressed; and tightly coiled.

9b Oblique side, showing low trochospiral, and last chamber, depressed.

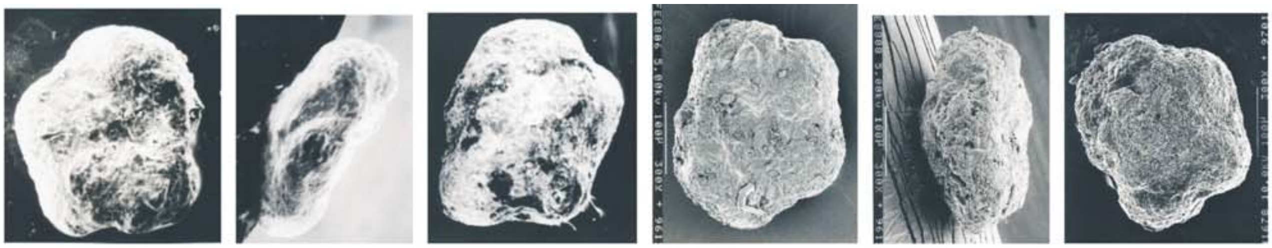
9c Spiral side, showing chambers in the last whorl, sutures slightly curved, radial and depressed. ×80. Scale is 100 micron.

10-11. *Parasubbotina trinidadensis* (Bolli)

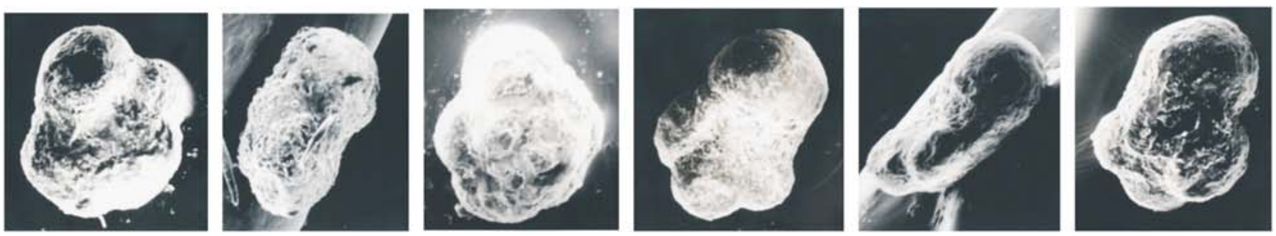
10a, 11a Umbilical sides of both forms, showing globular to subglobular chambers, 5 chambers in the last whorl; umbilicus fairly wide and depressed; and aperture interiomarginal, bordered by lip.

10b, 11b Lateral sides of both forms, showing test, biconvex; spiral side slightly convex and umbilical side slightly convex with central depression; and periphery rounded.

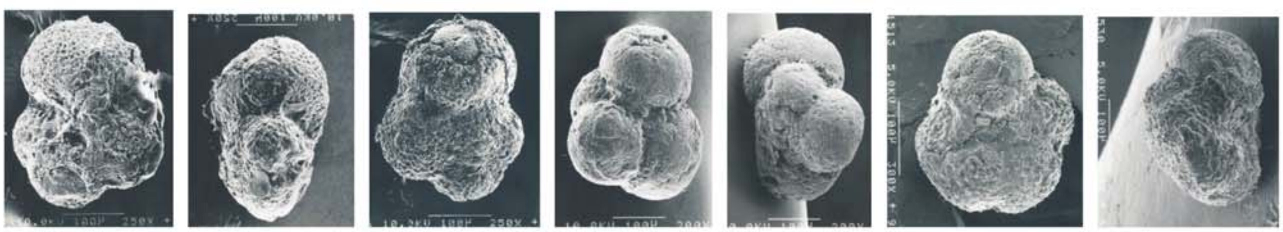
10c, 11c Spiral sides of both forms, showing chambers in the last whorl, sutures, slightly curved, radial and depressed. ×100. Scale is 100 micron.



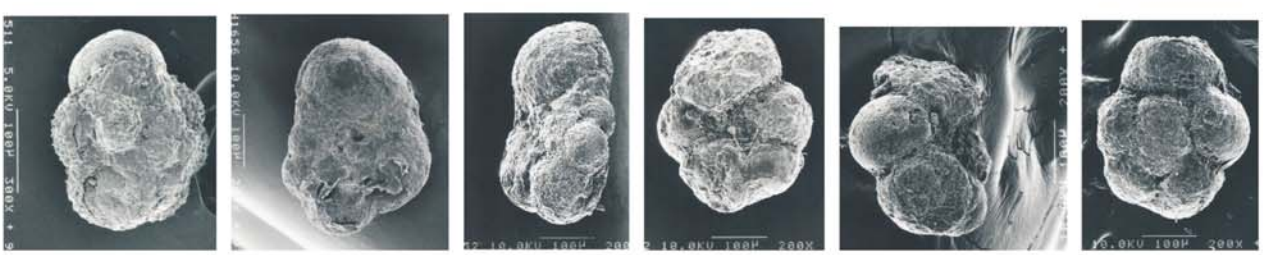
1a 1b 1c 2a 2b 2c



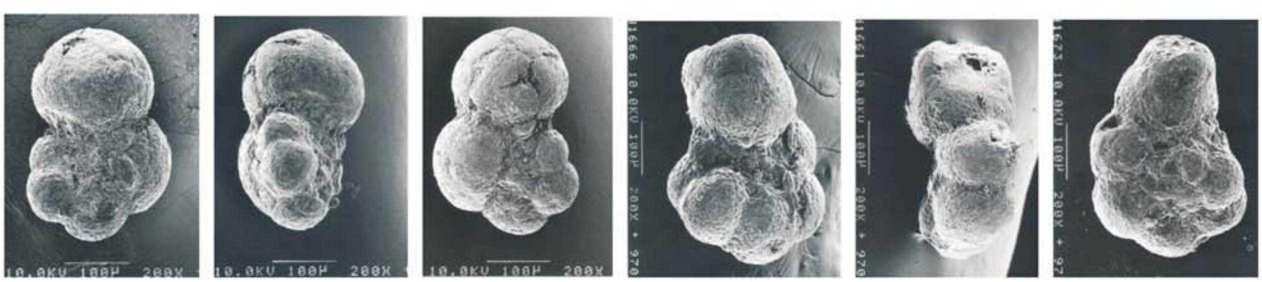
3a 3b 3c 4a 4b 4c



5a 5b 5c 6a 6b 7a 7b



7c 8a 8b 9a 9b 9c



10a 10b 10c 11a 11b 11c

Haymana, Anatoria and others, Turkey, based on the features of aperture with tooth or single aperture, but not cribrate aperture of the *Scandonea*. However, holotype of *Kayseriella decastroi* has sieveplate or trematophore with cribrate aperture in $13^{th}$ spiral chambers of the lower part of the test (Sirel 1999, pl. 1, fig. 6), and other form in the subaxial section shows trematophore in the proximal side of penultimate chamber (Sirel 1999, pl. 2, fig. 12). Also, his tooth, teeth and ribs caused by poor preservation of some forms are belonging to subepidermal partitions and trace of sieveplate or subepidermal network. The uniserial chamber in the horizontal section in *Haymanella paleocenica* (Sirel 1999, pl. 5, figure 2 right) shows the same feature of subepidermal partitions in the uniserial chamber of *Scandonea samnitica* (De Castro 1971, pl. 9, fig. 3). The slightly differences between both species (*H. paleocenica* and *S. samnitica*) are shown in shorter spiral coiling in *Haymanella paleocenica* than shorter to longer coiling in *Scandonea samnitica*, but there exists between wide variation of *Scandonea samnitica*. The present three forms (Plate 1, figures 6-8) of *Scandonea samnitica* from the Çaldağ Formation are identical to Sirel's *Haymanella paleocenica* due to short coiling, but the present two forms (Plate 1, figures 10-11) of *Scandonea samnitica* are identical to forms of *S. samnitica* (De Castro 1971, pl. 5, fig. 7; pl. 6, fig. 2). Also, *Scandonea samnitica* from the Çaldağ Limestone, Haymana (Meric 1984, pl. 1, figs. 1-6; pl. 2, figs. 1-6) are identical to *S. samnitica* (De Castro 1971, pls. 1-7, 11-12), although Sirel (1999, p. 128) denied Meric's *Scandonea samnitica*. As results, *Haymanella paleocenica* Sirel and *Kayseriella decastroi* Sirel are in accordance with *Scandonea samnitica* De Castro.

## CONCLUSION

The present study has been researched the larger benthonic foraminiferal assemblages in the Haymana and Black Sea regions, Turkey (Text-figures 1, 2) based on the accurate correlation of the biostratigraphical sequences of larger foraminifera with planktonic foraminiferal zones. This study introduced some element concentrations (patterns of iridium and other siderophiles) and strontium values in K-T boundary layers by the author's research group in order to confirm the mass extinction of biota (foraminifera). As it can be seen from Text-figures 5A, 5B, 6A, 6B, 10A, 10B, 11A and 11B, the total 11 larger foraminiferal assemblage zones for 13 divisions of the upper Campanian to Lutetian sedimentary rocks could be recognized at the first time in the Haymana and Black Sea regions, Turkey (Text-figures 12, 13). The correlation chart between larger foraminiferal assemblages in Turkey, those in Meghalaya, NE India (Matsumaru and Sarma 2010), and those of the Philippine Archipelago (Matsumaru 2011) is shown (Text-figure 12). Larger foraminiferal biostratigraphic research may, however, be required to improve more or less the present larger foraminiferal assemblage zones, due to analysis of abundant samples under the effects of sedimentation, diagenesis and local tectonic activity by identifying stratotypes for their exact boundaries.

## ACKNOWLEDGMENTS

The author has been supported by JSPS (Oversea Research Grand in 1992), Oversea Field Research (No. 7041086 in 1995 and No. 11640486 in 1999) by the Ministry of Education, Science and Culture, Japan, and Saitama University Grand in 1998 for this study, and expresses thanks. The author thanks Drs. Engin Meriç, Izver Tansel Öngen, Simav Bargu and Hayrettin Koral, all of Istanbul University; Drs. Kemal Erdoğan, Erciment Sirel, Sükre Acar, Sefer Örçen and Gulcan Tunay, all of General Directory of Mineral Research and Exploration (M.T.A.), Turkey; and Dr. Yoji Arakawa, Tsukuba University (formerly Saitama University), Japan, for their kind gift of samples, field survey, comments and facilities; Dr. John Van Couvering, Editor-in-Cief, and Dr. Harry Dowsett, of Micropaleontology; Dr. Danielle Decrouz, Muséum d'Histoire Naturelle de Genève, Suisse; and Dr. Ajanta Sarma, G. C. College, India, for their kind reading of the manuscript and comments.

## REFERENCES

AKYOL, Z., ERDOĞAN, B., GÖGER, E., GŰNEY, Y., SAROĞLU, F., SENTŰRK, I., UYSAL, Ş., 1974. *Geologic map of the Cide–Kurucasile region.* Ankara: Maden Tetkik ve Aram Enstit s . Geological map of Turkey (1:50,000) quadrangle series.

ALTINLI, I. E., 1973. Orta Sakarya jeolojisi: *Cumhuriyetin 50 nci yılı Yerbilimleri Kongresi Tebliğleri,* 159–191. Ankara: Maden Tetkik ve Arama Enstit s

ALVAREZ, L. W., ALVAREZ, W. , ASARO, F. and MICHEL, H. V., 1980. Extraterrestrial causes of the Cretaceous–Tertiary extinction. *Science*, 208: 1095–1108.

ANTHONISSEN, D. E. and OGG, J. G., 2012. Cenozoic and Cretaceous biochronology of planktonic foraminifera and calcareous nannofossils, In: Gradstein, F. M., Ogg, J. G., Schmitz, M. D. and Ogg, G. M., Eds., *The geologic time scale 2012, Volume 2,* 1082–1106. Amsterdam: Elsevier.

ARAKAWA, Y., AMAKAWA, H. and MATSUMARU, K., 2007. Elemental and Sr isotope profiles of the Cretaceous–Tertiary (K–T) boundary layers at Medetli, Gölpazari, northwestern Turkey. *Journal of Saitama University, Faculty of Education*, 56: 373–384.

ARAKAWA, Y., LI, X., EBIHARA, M., MERIÇ, E., TANSEL, I., BARGU, S., KORAL, H. and MATSUMARU, K., 2003. Element profiles and Ir concentration of Cretaceous–Tertiary (K–T) boundary layers at Medetli, Gölpazari, northwestern Turkey. *Geochemical Journal*, 37: 681–693.

BARGU, S. and SAKINÇ, M., 1987. Cretaceous–Paleocene relation in the Armutlu Peninsula. *Geological Bulletin of Turkey*, 30: 41–48.

———, 1989. The geology and the structural characteristics of the area between Gulf of Izmit and Lake Iznik. *Istanbul Universitesi, Mühendislik Fakültesi Yerbilimleri Dergisi*, 6: 45–76.

BERGGREN, W. A. and VAN COUVERING, J. A., 1974. *The late Neogene: biostratigraphy, geochronology and paleoclimatology of the last 15 million years in marine and continental sequences.* Amsterdam: Elsevier, 216 pp. (reprinted from *Paleogeography, Paleoclimatology, Paleoecology*, 16: 1–215.

BERGGREN, W. A., KENT, D. V., SWISHER, C. C III, and AUBRY, M.–P., 1995. A revised Cenozoic geochronology and chronostratigraphy. In: Berggren, W. A., Kent, D. V., Aubry, M.–P. and Hardenbol, J., Eds., *Geochronology, time scale and global stratigraphic correlation*, 129–212. Tulsa: Society of Economic Petrologists and Mineralogists. Special Publication 54.

BHANDARI, N., GUPTA, M., PANDEY, J. and SHUKLA, P. N., 1994. Chemical profiles in K/T boundary section of Meghalaya, India: cometary, asteroidal or volcanic. *Chemical Geology*, 113: 45–60.

BHANDARI, N., SHUKLA, P. N. and PANDEY, J., 1987. Iridium enrichment at Cretaceous/Tertiary boundary in Meghalaya. *Current Science*, 56: 1003–1005.

BIGNOT, G., 1972. Recherches stratigraphique sur les Calcaires du Crétacé supérieur et de l'Éocène d'Istrie et des régions voisines. *Éssai de révision du Liburnien. Travaux du Laboratoire de Micropaleontologie*, 2: 1–353.

BIGNOT, G. and NEUMANN, M., 1991. Les Grands Foraminifères du Crétacé terminal et du Paléogène du Nord–Ouest Européen. Recensement et extensions chronologiques. *Bulletin d'Information des Gologiques du Bassin de Paris*, 28: 13–29.

BLOW, W. H., 1969. Late Middle Eocene to recent planktonic foraminiferal biostratigraphy. In: Bronnimann, P. and Renz, H. H., Eds. *Proceedings of the First International Conference on Planktonic Microfossils, Volume 1*: 199–422. Leiden: E. J. Brill.

———, 1979. *The Cainozoic Globigerinida.* Leiden: E. J. Brill, vols. 1–3, 1413 pp.

CANUDO, J. I., KELLER, G. and MOLINA, E., 1991. Cretaceous/Tertiary boundary extinction pattern and fasunal turnover at Agost and Caravaca, S. E. Spain. *Marine Micropaleontology*, 17: 319–341.

CARON, M., 1985. Cretaceous planktic foraminifera. In: Bolli, H. M., Saunders, J. B., and Perch-Nielsen K., Eds., *Plankton stratigraphy, Volume 1*, 17–86. Cambridge: Cambridge University Press.

DE CASTRO, P., 1971. Osservazioni su Raadshoovenia van den Bold, e suoi rapporti col Nuevo genere Scandonea (Foraminiferida, Miliolacea). *Bollettino della Societa dei Naturalisti in Napoli*, 80: 161–235.

DEPAOLO, D. J. and INGRAM, B. L., 1985. High-resolution stratigraphy with strontium isotopes. *Science*, 227: 938–941.

DROBNE, K., OGORELEC, B., DOLENEC, T., MARTON, E. and PALINKAŠ, L., 1996. Biota and abiota at the K/T boundary in the Dolenja Vas sections, Slovenia. In: Katica, D., Gorican, S. and Kotnik, B., Eds., *The role of impact processes in the geological and biological evolution of planet earth,* 163–181. Ljubljana: Scientific Research Centre SAZU (Slovenska Akademija Znanosti In Umetnosti). International Workshop Sept. 27–Oct. 2, 1996, Postojna, Slovenia.

DROBNE, K., OGORELEC, B., PLENIČAR, M., ZUCCHI–STOLFA, M. L., and TURNŠEK, D., 1988. Maastrichtian, Danian and Thanetian beds in Dolenja Vas (NW Dinarides, Yugoslavia) Microfacies, foraminifers, rudists and corals. *Razprave IV. Razreda Sazu*, 29: 147–224.

DIZER, A. and MERIÇ, E., 1983. Kuzeybati Anadolu da Üst Kretase–Paleosen biyo-stratigrafisi. *M.T.A. Dertgisi,* 95/96: 149–163.

EHRENBERG, C. G., 1839. Über noch Jetzt zahlreich lebende Thiera-eten der Kreidebildung und den Organismus der Polythalamien. *Physikalische Abhandlungen der Königlichen Akademie dr Wissenschaften zu Berlin*, 1839: 81–174.

ELLIOT, D. H., ASKIN, R. A., KYTE, F. T. and ZINSMEISTER, W. J., 1994. Iridium and dinocysts at the Cretaceous–Tertiary boundary on Seymour Island, Antarctica: Implications for the K–T event. *Geology*, 22: 675–678.

FLEURY, J.–J., BIGNOT, G., BLONDEAU, A. and POIGNANT, A., 1985. Biogéographie de Foraminifères benthiques téthysiens de Sénonien à l'Éocene supérieur. *Bulletin de la Societe Géologique de France*, 8: 757–770.

GARG, R. and JAIN, K. P., 1995. Significance of the terminal Cretaceous calcareous nannofossil marker *Micula prinsii* at the Cretaceous–Tertiary boundary in the Um Sohryngkew section, Meghalaya, India. *Current Science*, 69: 1012–1017.

GORSEL, J. T. VAN, 1975. Evolutionary trends and stratigraphic significance of the late Cretaceous Helicorbitoides–Lepidorbitoides lineage. *Utrecht Micropaleontological Bulletins*, 12: 1–99.

KARAR, R. K., AMBWANI, K., DUTTA, D. and RATAN KAR, 2006. Major floral turnover at Mahadeo–Langpar formational boundary above K/T Iridium layer: Is it facies controlled? *Geological Society of India Journal*, 67: 180–188.

KAYA, O., DIZER, A., TANSEL, I. and MERIÇ, 1984. Stratigraphy of the Cretaceous in the Er li area, Zongludak. *M.T.A. Bulletin*, 99/100: 1–15.

KETIN, I. and G RM , O., 1963. *Sinop–Ayancik güneyinin jeolojisi*. Ankara: Turkish Petroleum Corporation (TPAO). Report 288.

LOEBLICH, A. R. JR. and TAPPAN, H., 1988. *Foraminiferal genera and their classification*. New York: Van Nordstrand and Reinhold Co., 970 pp.

MARTINI E. and MULLER, C., 1989. Current Tertiary and Quaternary calcareous nannoplankton stratigraphy and correlations. *Newsletters on Stratigraphy,* 16: 99–112.

MATSUMARU, K., 1997. On Pseudorbitoides trechmanni Douvillé (orbitoidal foraminifera) from Turkey. *Revue de Micropaléontologie*, 40: 339–346.

———, 2011. A new definition of the letter stages in the Philippine Archipelago. *Stratigraphy*, 8: 237–252.

MATSUMARU, K. and SARMA, A., 2010. Larger foraminiferal biostratigraphy of the lower Tertiary of Jaintia Hills, Meghalaya, NE India. *Micropaleontology*, 56: 539–565.

MATSUMARU, K., MERIÇ, E., ARAKAWA, Y., ÖZKAR, I., BARGU, S., and KORAL, H., 1998, Geochemical evidence of the Cretaceous–Tertiary boundary sediments in Turkey (Part 2). *Journal of Saitama University, Faculty of Education* (*Mathmatics and Natural Sciences*), 47: 35–39.

MATSUMARU, K., MERIÇ, E., TANSEL, I., ARAKAWA, Y., BARGU, S., KORAL, H., and AMAKAWA, H., 1996. Geohistorical study of foraminiferal biostratigraphy and ecological change of Cretaceous–Tertiary transitional formations in the Black Sea region, Republic of Turkey. *Journal of Saitama University, Faculty of Education (Mathmatics and Natural Sciences)*, 45: 19–37.

———, 1997. Geochemical aspect of shallow foraminiferal sediments of the K–T boundary in Medetli section, Gölpazari, Turkey. *Journal of Saitama University, Faculty of Education (Mathmatics and Natural Sciences*), 46: 11–19.

MATSUMARU, K., SARI, B., and ÖZER, S., 2010. Larger foraminiferal biostratigraphy of the middle Tertiary of Bey Daglari Autochton, mendered–Taurus Platform, Turkey. *Micropaleontology*, 56: 439–463.

MERIÇ, E., 1984. *Scandonea* De Castro (1971) nin Paleosen'deki varligi hakkinda. *Bulletin of the Geological Society of Turkey*, 22: 41–44.

MERIÇ, E. and SENGULAR, I., 1986. New observations on the stratigraphy of upper Cretaceous – Paleocene around Göynük (Bolu, Northwest Anatolia). *Geological Engineering*, 29: 61–64.

MOLINA, E., ARENILLAS, I. and JOSŚ, A. ARZ, 1996. The Cretaceous/Tertiary boundary mass extinction in planktic foraminifera at Agost, Spain. *Revue de Micropaléontologie*, 39: 225–243.

M.T.A. [General Directory of Mineral Research Exploration], Eds., 1992. *Introduction to the Early Paleogene of the Haymana–Polatli Basin. Field-Trip Guidebook. IGCP Project N. 286: Early Paleogene Benthos Third Meeting, Ankara (Turkey).* Ankara: General Directory of Mineral Research and Exploration.

MUKHOPADHYAY, S., 2008. Planktonic foraminiferal succession in late Cretaceous to early Paleocene strata in Meghalaya, India. *Lethaia*, 41: 71–84.

MURALI, A. V., BLANCHARD, D. P., BHANDARI, N., and MACDOUGALL, J. D., 1990. Relationship of Deccan volcanism to global K–T biotic extinctions: A case of unfounded assumptions? *Lunar and Planetary Science Conference*, 21: 819–820.

NEAGU, T., 1968. Study of the Miliolidaceae in the lower Cretaceous (Barremian) of Southern Dobrogea. In "The Centenary Grigore Antipa, 1867–1967". *Traveaux du Museum d'Histoire Naturelle "Grigore Antipa" Bucarest,* 8: 563–572.

ÖZCAN, E. and ÖZCAN ALTINER, S., 1997. Late Campanian–Maastrichtian evolution of orbitoidal foraminifera in Haymana Basin succession (Ankara, Central Turkey). *Revue du Paléobiologie*, 16: 271–290.

———, 1999. The genus Lepidorbitoides: Evolution and stratigraphic significance in some Anatolian basins (Turkey). *Revue de Micropaléontologie*, 42: 111–131.

PALMER, M. R. and ELDERFIELD, H., 1985. Sr isotopic composition of sea water over the past 75 Myr. *Nature*, 314: 526–528.

PANDEY, J., 1981. Cretaceous foraminifera of Um Sohryngkew River section, Meghalaya. *Journal of the Palaeontological Society of India*, 25: 53–74.

———, 1990. Cretaceous/Tertiary boundary, iridium anomaly and foraminifer breaks in the Um Sohryngkew river section, Meghalaya. *Current Science*, 59, 570–575.

POSTUMA, J. A., 1971. *Manual of planktonic foraminifera*. Amsterdam: Elsevier, 420 pp.

SCHWAGER, C., 1876. Saggio di una classificazione dei foraminiferi avuto riguardo alle loro famiglie naturali. *Bolletino R. Comitato Geologico d'Italia,* 7: 1–485.

SERRA-KIEL, J., HOTTINGER, L., CAUS, E., DROBNE, K., FERRANDEZ, C., JAUHRI, A. K., LESS, G., PAVROVEC, R., PIGNATTI. J., SAMSO, J. M., SCHAUB, H., SIREL, E., STROUGO, A., TAMBAREAU, Y., TOSQUELLA, J. and ZAKREVSKAYA, E., 1998. Larger foraminiferal biostratigraphy of the Tethyan Paleocene and Eocene. *Bulletin de la Société Géologique de France*, 169: 281–299.

SIREL, E., 1973. Description of a new Cuvillierina species from the Maestrichtian of Cide (northern Turkey). *Bulletin of the Geological Society of Turkey*, 16: 69–76.

———, 1976. Systematic studyof the some species of the genera Alveolina, Nummulites, Ranikothgalia and Assilina in the south of Polatli (SW Ankara). *Bulletin of the Geological Society of Turkey*, 19: 89–102.

———, 1991. Cideina, a new foraminiferal genus from the Maastrichtian limestone of the cide region (north Turkey). *Bulletin of the Mineral Research and Exploration,* 112: 65–70.

———, 1992. Introduction to the Paleogene of central Turkey. In: M.T.A., Eds., *Introduction to the Early Paleogene of the Haymana–Polatli Basin. Field–Trip Guidebook. IGCP Project. No. 286, Early Paleogene Benthos Third Meeting, Ankara (Turkey),* 1–10. General Directory of Mineral Research and Exploration,

———, 1995. Occurrence of the genus Helicorbitoides MacGillavry (Foraminiferida) in Turkey. *Revue de Paléobiologie*, 14: 85–94.

———, 1999. Four new genera (Haymanella, Kayseriella, Elazigella and Orduella) and one new species of Hottingerina from the Paleocene of Turkey. *Micropaleontology*, 45: 113–137.

SLITER, W. V., 1989. Biostratigraphic zonation for Cretaceous planktic foraminifers examined in thin section. *Journal of Foraminiferal Research*, 19: 1–19.

SMIT, J., 1982. Extinction and evolution of planktonic foraminifera after a major impact at the Cretaceous/Tertiary boundary. In: Silver, L. T. and Schultz, P. H., Eds., *Geological implications of impacts of large asteroids and comets on the Earth* , 329–352. Boulder: Geological Society of America. Special Paper 190..

TANSEL, I., 1989. Late Cretaceos–Paleocene boundary and the Paleocene biostratigraphy of Ağva (Istanbul) region. *TAPG Bulletin*, 1: 211–228.

TOKER, V., 1980. Nannoplankton biostratigraphy of the haymana region (SW Ankara). *Bulletin of the Geological Society of Turkey,* 23: 165–178.

TOUMARKINE, M. and LUTERBACHER, H., 1985. Paleocene and Eocene planktic foraminifera. In: Bolli, H. M., Saunders, J. B. and Perch-Nielsen, K., Eds., *Plankton stratigraphy,* 87–154. Cambridge: Cambridge University Press.

ÜNALAN, G., YUKSEL, V., TEKELI, T., GONENC, D., SEYIRT, Z. and HUSEYIN, S., 1976. The stratigraphy and paleogeographical evolution of the upper Cretaceous–lower Tertiary sediments in the Haymana–Polatli region (SW of Ankara). *Bulletin of the Geological Society of Turkey*, 19: 159–176.