On the variability of benthic foraminiferal species of the agglutinated genus *Spiroplectinella* in the Tethys

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Abstract: Thirty three small diagnostic benthic foraminiferal species of the Textulariid genus *Spiroplectinella* are common in the late Cretaceous, Paleogene and Neogene rocks from many Tethyan localities: North Atlantic (USA, Mexico, Caribbean), South Atlantic (Brazil, Argentina, Chile Venezuela, Ecuador), Europe (North Sea, Norway, France, Poland, Italy, Hungary, Slovenia, Croatia, Romania, Bulgaria, Ukraine, Turkmenistan), North Africa (Tunisia, Egypt), Southwest Asia (Turkey, Iraq, Jordan, UAE, Iran), and Indian Ocean (Pakistan, Australia, Antarctic Basin). These diagnostic species are: *Spiroplectinella adamsi, baudouiniana, carinata, chicoana, costata, cretosa, dalmatina, dentata, deperdita, desertorum, elongata, esnaensis, excolata, hamdani, henryi, israelski, jarvisi, knebeli, laevis, longa, nuttalli, paleocenica, paracarinata, pectinatiforma, plummerae, praelonga, richardi, rossae, semicomplanata, sigmoidina, subhaeringensis, wilcoxensis* and *wrightii*. The paleontology, stratigraphy, paleoenvironment and paleogeographic distribution of them in the Tethys throughout Late Cretaceous and Paleogene are presented and discussed.
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Introduction

The rich and diverse late Cretaceous-Paleogene benthic foraminiferal assemblages from Tethys include different species of the Textulariid genus *Spiroplectinella* Kisel'man, 1972 (pl. 1, fig. 1) with early planispiral coil and lozenge shaped in section, than large early planispiral coil and broadly rounded margins in the genus *Spiroplectammina* Cushman,1927 (pl. 1, fig. 2), or large planispiral coil in early stage and later long and narrow biserial stage in the genus *Bolivinopsis* Yakovlev, 1891 (pl. 1, fig. 3). The paleontological occurrence of thirty three species belonging to the genus *Spiroplectinella* has been reported, and have a wide geographic distribution in many localities in the Tethys throughout the Late Cretaceous (Fig. 1) and Middle Eocene (Fig. 2). As a whole, these taxa are rarely described and scattered in the micropaleontological literature, that's why this study is dedicated. The author has examined many representatives of the genus *Spiroplectinella*, which has different length and width, and existed in different Tethyan localities, particularly in Europe (France, Italy, Austria, Slovenia, Hungary), South Tethys (Egypt, UAE, Iran, Pakistan - Fig. 3), and North and South America (USA, Mexica, Trinidad, Venezuela, Ecuador, Brazil, Argentina, Chile - Fig. 4). The intent of this study is to bring together many data scattered in the literature under a unifying theme, and to detect its paleontology, stratigraphy, paleobathymetry, paleoenvironment and paleogeographic distribution of them in the Tethys (Table 1) throughout the Late Cretaceous and Paleogene (Figs. 1, 2).

Systematic Paleontology

Thirty three species of benthic foraminiferal genus *Spiroplectinella* were identified following the taxonomic classification of Kaminski (2014) and the illustrated taxa have been shown in Plates (1, 2).

Class Foraminifera d'Orbigny, 1826
Subclass Monothalamana Pawlowski, Holzmann and Tyszka, in Kaminski 2013
Order Allogromiida Hartog in Harmer and Shipley 1906
Suborder Spiroplectamminina Mikhalevich 1992
Superfamily Spiroplectamminoidea Cushman 1927
Family Spiroplectamminidae Cushman 1927
Subfamily Spiroplectammininae Cushman 1927
Genus *Spiroplectinella* Kisel'man 1972
Type species: *Spiroplecta wrightii* Silvestri 1903

***Spiroplectinella adamsi* (Lalicker, 1935) - Pl. 1, fig. 4**

1935 *Spiroplectammina adamsi* Lalicker, p. 39, pl. 6, figs. 1, 2.

1992 *Spiroplectammina adamsi* Lalicker - Cherif et al., p. 46, pl. 1, fig. 1.●

2005 *Spiroplectammina adamsi* Lalicker - Abawi and Hani, p. 49.

2011 *Spiroplectammina adamsi* Lalicker - Marchant, p. 16, pl. 2, fig. 8.

This Paleocene-Oligocene species was recorded from USA (Lalicker, 1935), Chile (Marchant, 2011), UAE (Cherif et al, 1992), Iraq (Abawi and Hani, 2005) .

***Spiroplectinella baudouiniana* (d'Orbigny, 1840) - Pl. 1, fig. 5**

1840 *Textularia baudouiniana* d'Orbigny, p. 46, pl. 4, figs. 29, 30.

1965 *Spiroplectammina baudouiniana* d'Orbigny - Pozaryska, p. 48, pl. 2, fig. 5. ●

1992 *Spiroplectammina baudouiniana* d'Orbigny - Gawor-Biedowa, p. 26, pl. 2, figs. 9, 10.

This Campanian-Paleocene species has rhomboidal transverse section of the test, sharp margins, location of the maximum bulge of the test along its length axis. The largest quartz grains occur in the same region of the test in Poland. It was recorded, so far, in France (d'Orbigny, 1840) and Poland (Pozaryska, 1965; Gawor-Biedowa, 1992).

***Spiroplectinella carinata* (d'Orbigny, 1846) - Pl. 1, fig. 6**

1846 *Textularia carinata* d'Orbigny, p. 247, pl. 14, figs. 32–34.

1959 *Spiroplectammina carinata* (d'Orbigny) - Nakkady, p. 456, pl. 1, fig. 1.

1992 *Spiroplectammina carinata* (d'Orbigny) - Cherif et al., p. 46, pl. 1, fig. 2.

2006 *Spiroplectinella carinata* (d'Orbigny) - Ortiz and Thomas, p. 109, pl. 2, figs. 4, 5.

2016 *Spiroplectinella carinata* (d'Orbigny) - VahdatiRad et al., p. 6, pl. 2, fig. 21.

2019 *Spiroplectinella carinata* (d'Orbigny) - Darakchieva et al., p. 12, pl. 1, fig. 7. ●

The species has oval compressed test, limbate raised sutures and irregular marginal keel. It was recorded in Danian of Egypt (Nakkady, 1959), Early Eocene of Iran (VahdatiRad et al., 2016), Early-Middle Eocene of Spain (Ortiz and Thomas, 2006), Oligocene of UAE (Cherif et al., 1992), Eocene-Miocene of Bulgaria (Darakchieva et al., 2019).

***Spiroplectinella chicoana* (Lalicker, 1935) - Pl. 1, fig. 7**

1935 *Spiroplectammina chicoana* Lalicker, p. 7, pl. 1, figs. 8, 9.

1968 *Spiroplectammina chicoana* Lalicker - Sliter, p. 46, pl. 2, fig. 8.

1972 *Spiroplectammina chicoana* Lalicker - Hanzlíková, p. 47, pl. 9, fig. 7.

1992 *Spiroplectammina chicoana* Lalicker - Gawor-Biedowa, p. 27, pl. 1, figs. 6, 7.

1994 *Quasispiroplectammina chicoana* Lalicker - Bolli et al., p. 82, fig. 21. 28, 29. ●

2005 *Spiroplectammina chicoana* Lalicker - Sztrákos, p. 184, pl. 2, fig. 13.

This species is characterized by its elongate its and irregular periphery. It was recorded from Campanian-Paleocene of USA (Lalicker, 1935), Mexico (Sliter, 1986), Trinidad (Bolli et al., 1994), Poland (Gawor-Biedowa, 1992), France (Sztrákos, 2005).

***Spiroplectinella costata* (Huss, 1966) - Pl. 1, fig. 8**

1966 *Spiroplectammina costata* Huss, p. 33, pl. 6, figs. 18, 19.

1981 *Spiroplectammina costata* Huss - Morgiel and Olszewska, p. 14, pl. 4, fig. 3.

1995 *Spiroplectammina costata* Huss - Bubík, p. 87, pl. 15, fig. 1. ●

2017 *Spiroplectinella costata* Huss - Birkenmajer and Gedl, p. 79.

Gawor-Biedowa (1992) considered the specimen *S. chicoana* of Hanzlíková (1972, pl. 9, fig. 7) belongs to the species *S. costata* as it has identical shape of the test, and sutural thickenings elongated into spines. It was recorded, so far, from Poland (Morgiel and Olszewska, 1981; Birkenmajer and Gedl, 2017) and Czech (Bubík, 1995).

***Spiroplectinella cretosa* (Cushman, 1932) - Pl. 1, fig. 9**

1932 *Spiroplectammina laevis* (Roemer) var. *cretosa* Cushman, p. 87, pl. 11, fig. 3.

1972 *Spiroplectammina cretosa* Cushman - Hanzlíková, p. 47, pl. 10, fig. 9. ●

Hanzlíková (1972) noted that the species *S. cretosa* was recorded as S. laevis from the European Campanian-Maastrichtian platform of Germany and Netherland by Hofker (1966) and it was recorded from USA, Germany, Netherland, Czech and Australia.

***Spiroplectinella dalmatina* (de Witt Puyt, 1941) - Pl. 1, fig. 10**

1941 *Textularia dalmatina* de Witt Puyt, p. 45, pl. 1, figs. 4, 5.

1975 *Spiroplectammina dalmatina* de Witt Puyt - Braga and Grünig, p. 102.

2006 *Spiroplectinella dalmatina* de Witt Puyt - Cimerman et al., p. 16, pl. 1, fig. 4.

2007 *Spiroplectammina dalmatina* de Witt Puyt - Zivkovic and Glumac, p. 304, pl. 2, fig.10. ●

This Eocene species has tapering test with acute periphery with faint keel, raised center of the test, and raised suture lines. It was recorded from Italy (Braga and Grünig, 1975), Slovenia (Cimerman et al., 2006) and Croatia (Zivkovic and Glumac, 2007).

***Spiroplectinella dentata* (Alth, 1850) - Pl. 1, fig. 11**

1850 *Textularia dentata* Alth, p. 262, pl. 13, fig. 13.
1932 *Spiroplectammina dentata* Alth - Cushman and Jarvis, p. 14, pl. 3, fig. 7.
1956 *Spiroplectammina dentata* Alth - Said and Kenawy, p. 121, pl. 1, fig. 9.
1972 *Semivulvulina dentata* Alth - Hanzlíková, p. 49, pl. 9, fig. 6; pl. 10, fig. 10.
1975 *Spiroplectammina dentata* Alth - Proto Decima and De Biase, p. 91, pl. 1, fig. 5.
1976 *Spiroplectammina dentata* Alth - Aubert and Berggren, p. 408, pl. 1, fig. 5.
1993a *Spiroplectammina dentata* Alth - Anan, p. 314, pl. 1, fig. 3.
1994 *Spiroplectinella dentata* Alth - Bolli et al., p. 83, fig. 22.4-7. ●
1995 *Spiroplectammina dentata* Alth - Bubík, p. 87, pl. 7, fig. 10.
2005 *Spiroplectammina dentata* Alth - Sztrákos, p. 184, pl. 2, fig. 10.
2008 *Spiroplectammina dentata* Alth - Sharbazheri, p. 46, fig. 3.2.
2015 *Spiroplectinella dentata* Alth - Anan, p. 245, fig. 4.11.
2019 *Spiroplectammina dentata* Alth - Bejaoui et al., p. 523, fig. 11. 6.

Hanzlíková (1970) noted that neither the original (Alth, 1850) nor subsequent descriptions do record the arrangement of the earliest portion of the test of this species and assigned by her to the genus *Semivulvulina* (biserially arranged test throughout) until the originals have been revised. This Maastrichtian-Paleocene cosmopolitan species was recorded in many Tethyan localities: USA (Cushman and Jarvis, 1932), Czech (Hanzlíková, 1972), Italy (Proto Decima and De Biase, 1975), Trinidad (Bolli et al., 1994), France (Sztrákos, 2005), Poland (Bubík, 1995), Tunisia (Aubert and Berggren, 1976; Bejaoui et al., 2019), Egypt (Said and Kenawy, 1956; Anan, 2015), Iraq (Sharbazheri, 2008), UAE (Anan, 1993a, 2015).

***Spiroplectinella deperdita* (d'Orbigny, 1846) - Pl. 1, fig. 12**

1846 *Textularia deperdita* d'Orbigny, p. 244, pl. 14, figs. 23–25.
2007 *Textularia deperdita* d'Orbigny - Ozsvárt, p. 35, pl. 2, figs. 1, 2.
2019 *Spiroplectammina deperdita* d'Orbigny - Darakchieva et al., p. 11, pl. 1, fig. 6.●

The species has elongate test with small planispiral initial and biserial late portion, which comprises 8–9 pairs of broad, low, flattened chambers, gradually increasing towards the apertural end, sutures are depressed and slightly oblique, periphery thin and sharp, aperture arch-shaped and low. It was recorded in the middle Eocene-Oligocene of Bulgaria (Darakchieva, 1999; Darakchieva et al., 2019), but Eocene of Hungary (Ozsvárt, 2007).

***Spiroplectinella desertorum* (LeRoy, 1953) - Pl. 1, fig. 13**

1953 *Spiroplectammina desertorum* LeRoy, p. 50, pl. 1, figs. 19, 20. ●
2011 *Spiroplectinella desertorum* LeRoy - Aly et al., p. 83, pl. 1, fig. 7.

This Eocene species has tapering initial end to greatest width at the apertural extremity, slightly convex downward sutures, semiacute periphery, smoothly finished wall. It differs from S. paleocenica Cushman by being less thick through the median portion and by lacking the slightly upturned sutures. It is, so far, an endemic to Egypt.

***Spiroplectinella elongata* (Davis, 1941) - Pl. 1, fig. 14**

1941 *Textularia mississippiensis* var. *elongata* Davis, p. 151, pl. 24, figs. 21, 22.
1956 *Textularia mississippiensis* var. *elongata* Davis - Haque, p. 30, pl. 9, figs. 3, 13.●

This species belongs to the genus *Spiroplectinella* due to its planispiral initial stage and biserial end stage. It was recorded from Eocene-Oligocene in USA (Davis, 1941) and Pakistan (Haque, 1956).

***Spiroplectinella esnaensis* (LeRoy, 1953) - Pl. 1, fig. 15**

1953 *Spiroplectammina esnaensis* LeRoy, p. 50, pl. 1, figs. 11, 12. .●
1976 *Spiroplectammina esnaensis* LeRoy - Aubert and Berggren, p. 409, pl. 1, fig. 6.
1994 *Spiroplectinella esnaensis* LeRoy - Speijer, p. 147, pl. 3, fig. 1.
2005 *Spiroplectammina esnaensis* LeRoy - Sztrákos, p. 184, pl. 12, fig. 16.
2007 *Spiroplectinella esnaensis* LeRoy - Alegret and Ortiz, p. 437, pl. 1, fig. 6.
2011 *Spiroplectinella esnaensis* LeRoy - Aly et al., p. 83, pl. 1, fig. 8.
2016 *Spiroplectinella esnaensis* LeRoy - Anan, p. 356, fig. 3h.
2016 *Spiroplectinella esnaensis* LeRoy - VahdatiRad et al., p. 6, pl. 2, fig. 20.
2017 *Spiroplectinella esnaensis* LeRoy - Hewaidy et al., p. 83, pl. 2, fig. 7.

The Paleocene-Early Eocene *S. esnaensis* (LeRoy) species was recorded in Egypt (LeRoy, 1953; Speijer, 1994; Aly et al., 2011; Anan, 2016; Hewaidy *et al.*, 2017), Iran (VahdatiRad et al., 2016), Tunisia (Aubert and Berggren, 1976) and France (Sztrákos, 2005).

***Spiroplectinella excolata* (Cushman, 1926) - Pl. 1, fig. 16**

1926 *Textularia excolata* Cushman, p. 585, pl. 15, fig. 9.
1932 *Spiroplectammina excolata* Cushman - Cushman and Jarvis, p. 14, pl. 3, figs. 9, 10.
1982 *Spiroplectammina excolata* Cushman - Proto Decima and Bolli, p. 119, pl. 6, fig. 21.
1988 *Spiroplectammina excolata* Cushman - Kaminski et al., p. 192, pl. 7, fig. 12.
1994 *Spiroplectinella excolata* Cushman - Bolli et al., p. 84, fig. 22. 8, 17.●
2008 *Spiroplectammina excolata* Cushman - Filipescu and Kaminski, p. 27, pl. 1, fig. 11.

Szczechura and Pozaryska, 1974 (in Tjalsma and Lohmann, 1983) and the latter authors, as well as Darakchieva et al. (2019) treated the *S. excolata* (Cushman) as a junior synonym of *S. subhaeringensis* (Grzybowski), while the present author and others considered *S. excolata* as a separate species than *S. subhaeringensis*. It was recorded from USA (Cushman, 1926), Trinidad (Kaminski et al., 1988; Bolli et al., 1994) Italy (Proto Decima and Bolli, 1982) and Romania (Filipescu and Kaminski, 2008).

***Spiroplectinella hamdani* (Anan, 1993) - Pl. 2, fig. 17**

1993b *Spiroplectammina hamdani* Anan, p. 652, pl. 1, fig. 14. ●
2005 *Spiroplectinella hamdani* Anan - Anan, p. 79, pl. 1, fig. 2.
2011 *Spiroplectinella hamdani* Anan - Anan, p. 15, pl. 1, fig. 4.
2021 *Spiroplectinella hamdani* Anan - Anan, p. 85, pl. 1, fig. 7.

This Maastrichtian species is characterized by its large coiled early stage, elongate later biserial stage and high raised sutures. It was recorded, so far, from UAE and Egypt.

***Spiroplectinella henryi* (LeRoy, 1953) - Pl. 2, fig. 18**

1953 *Spiroplectammina henryi* LeRoy, p. 45, pl. 2, figs 14, 15.●
1956 *Spiroplectammina henryi* LeRoy - Said and Kenawy, p. 121, pl. 1, fig. 11.
1974 *Spiroplectammina henryi* LeRoy - Berggren, p. 452, text-fig. 4.
2003 *Spiroplectinella henryi* (LeRoy) - Ali, p. 124, pl. 4, figs. 9, 10.
2011 *Spiroplectinella henryi* (LeRoy) - Anan, p. 15, pl. 1, fig. 5.
2014 *Spiroplectinella henryi* (LeRoy) - Hewaidy et al., p. 20, pl. 3, fig. 20.

The Maastrichtian-Paleocene species is characterized by its sharply rounded initial portion, raised sutures and strongly arched downward and acute periphery. It was recorded in many localities of Egypt and Libya.

***Spiroplectinella israelskyi* (Hillebrandt, 1962) - Pl. 2, fig. 19**

1962 *Spiroplectammina israelskyi* Hillebrandt, p. 30, pl. 1, figs. 5-7.
1993 *Spiroplectammina israelskyi* Hillebrandt - Kuhnt and Kaminski, p. 75, pl. 6, fig. 3.●
1997 *Spiroplectammina israelskyi* Hillebrandt - Widmark, p. 18, fig. 6B.
2008 *Spiroplectammina israelskyi* Hillebrandt - Kaminski et al., p. 92, pl. 5, fig. 9.

This Maastrichtian species differs from *S. dentata* in its more elongate test and lack the peripheral spines of it. It also differs from S. laevis in being less tapered and in having invaginations between the chambers along the periphery in the biserial part of the test. It was recorded, so far, from Austria (Hillebrandt, 1962), Spain (Kuhnt and Kaminski, 1993) and Italy (Kaminski et al., 2008).

***Spiroplectinella jarvisi* (Cushman, 1939) - Pl. 2, fig. 20**

1939 *Spiroplectammina jarvisi* Cushman, p. 90, pl. 16, fig. 1.
1994 *Quasispiroplectammina jarvisi* (Cushman) - Bolli et al., p. 83, fig. 22. 1, 2. ●
2005 *Spiroplectammina jarvisi* Cushman - Nomura and Takata, p. 15, pl. 2, fig. 8.
2016 *Spiroplectammina jarvisi* Cushman - Mello, p. 250, pl. 4, fig. 7.

Bolli et al. (1994) noted that *S. israelskyi* may be a junior synonym of *S. jarvisi*. This Paleocene species was recorded from USA (Cushman, 1939), Trinidad (Bolli *et al*., 1994), Pacific Ocean (Nomura and Takata, 2005) and Brazil (Mello, 2016).

***Spiroplectinella knebeli* (LeRoy, 1953) - Pl. 2, fig. 21**

1953 *Spiroplectammina knebeli* LeRoy, p. 51, pl. 2, figs. 10, 11.
1956 *Spiroplectammina knebeli* LeRoy - Said and Kenawy, p. 121, pl. 1, fig.10.
1976 *Spiroplectammina knebeli* LeRoy - Aubert and Berggren, p. 409, pl. 1, fig. 7
1976 *Spiroplectammina knebeli* LeRoy - Futyan, p. 521.
1985 *Spiroplectammina knebeli* LeRoy - Luger, p. 76, pl. 3, fig. 2.

1993a *Spiroplectammina knebeli* LeRoy - Anan, p. 314, pl. 1, fig. 4.
2003 *Spiroplectinella knebeli* (LeRoy) - Ali, p. 124, pl. 4, figs. 14, 15.
2011 *Spiroplectinella knebeli* (LeRoy) - Anan, p. 16, pl. 1, fig. 6.
2017 *Spiroplectinella knebeli* (LeRoy) - Hewaidy et al., p. 83, pl. 2, fig. 8.
2020 *Spiroplectinella knebeli* (LeRoy) - Anan, p. 64, pl. 1, fig. 2a.

This Maastrichtian-Paleocene species has small coiled planispiral stage, biserial chambers low, sutures slightly raised and curved downward and broad convex apertural face. It was recorded in Egypt (LeRoy, 1953; Luger, 1985; Ali, 2003; Hewaidy *et al*., 2017; Anan, 2020), Tunisia (Aubert and Berggren, 1976), Jordan (Futyan, 1976) and UAE (Anan, 1993a).

***Spiroplectinella laevis* (Roemer, 1841) - Pl. 2, fig. 22**

1841 *Textularia laevis* Roemer, p. 97, pl. 15, fig. 17.
1968 *Spiroplectammina laevis* (Roemer) - Sliter, p. 46, pl. 2, fig. 9.
1993 *Spiroplectammina laevis* (Roemer) - Kuhnt and Kaminski, p. 75, pl. 6, fig. 4.
1995 *Spiroplectammina laevis* (Roemer) - Bubík, p. 87, pl. 14, figs. 6, 7.
1997 *Spiroplectammina laevis* (Roemer) - Widmark, p. 19, fig. 6C.
2002 *Spiroplectammina laevis* (Roemer) - Quilty, p. 16.
2008 *Spiroplectammina laevis* (Roemer) - Sharbazheri, p. 46, pl. 19, fig. 9.
2011 *Spiroplectinella laevis* (Roemer) - Anan, p. 296, pl. 1, fig. 1. ●
2014 *Spiroplectinella laevis* (Roemer) - Hewaidy et al., p. 20, pl. 3, fig. 22.

Spiroplectinella laevis has tapering test with acute periphery, raised ridges at the suture lines which forming a raised zigzag line along the center of the test. It has been originally described from the Cretaceous of Germany, and later on from USA, Mexico (Sliter, 1968), Spain (Kuhnt and Kaminski, 1993), Czech (Bubík, 1995), Egypt (Anan, 2011; Hewaidy et al., 2014) and Iraq (Sharbazheri, 2008), Indian Ocean (Quilty, 2002).

***Spiroplectinella longa* (Said and Kenawy, 1956) - Pl. 2, fig. 23**

1956 *Spiroplectammina knebeli longa* Said and Kenawy, p. 122, pl. 1, fig. 12.
2014 *Spiroplectinella longa* (Said and Kenawy) - Hewaidy et al., p. 20, pl. 4, fig. 1. ●

This Maastrichtian-Paleocene species differs from *S. knebeli* in having a longer test, and having more later biserial chambers. It is, so far, an endemic to Egypt.

***Spiroplectinella nuttalli* (Lalicker, 1935) - Pl. 2, fig. 24**

1935 *Spiroplectammina nuttalli* Lalicker, p. 43, p1. 6, figs 3, 4.
1951 *Spiroplectammina nuttalli* Lalicker - Cushman and Stainforth, p.143, p1. 25, figs 19, 20.
1955 *Bolivinopsis nuttalli* (Lalicker) - Ansary, p. 19, p1. 1, fig. 7.
2005 *Spiroplectinella nuttalli* (Lalicker) - Anan, p. 20, pl. 1, fig. 6. ●

This Eocene species is characterized by large triangular test with acute periphery. It was originally described from Venezuela (Lalicker, 1935), Ecuador (Cushman and Stainforth, 1951), Egypt (Ansary, 1955), UAE (Anan, 2005).

***Spiroplectinella paleocenica* (Cushman, 1947) - Pl. 12, fig. 25**

1947 *Spiroplectammina paleocenica* Cushman, p. 81, pl. 17, fig. 17.
1951 *Spiroplectammina paleocenica* Cushman - Cushman, p. 7, pl. 1, fig. 27. ●

Test very small, evenly tapering from the slightly rounded initial end to the greatest width at the apertural end, wall finely arenaceous, smoothly finished; aperture a slight, low opening at the base of the inner margin of the last-formed chamber. It is , so far, an endemic to USA (Cushman, 1947).

***Spiroplectinella paracarinata* (Said and Kenawy, 1956) - Pl. 2, fig. 26**

1956 *Spiroplectammina paracarinata* Said and Kenawy, p. 122, pl. 1, fig. 13.
1996 *Spiroplectammina paracarinata* Said and Kenawy - Anan, p. 149, fig. 3. 2.
2012 *Spiroplectinella paracarinata* (Said and Kenawy) - Anan, p. 63, pl. 1, fig. 6.●
2020 *Spiroplectinella paracarinata* (Said and Kenawy) - Anan, p. 64, pl. 1, fig. 2b.

Anan (2012) recognized five phylogenetic lineages based mainly on the change in shell morphological characters of some benthic foraminifera in the Maastrichtian-early Eocene succession, particularly around the K/T and P/E boundaries in Egypt and other parts in the Tethys, and one of them is the lineage of the Maastrichtian-Paleocene *S. knebeli* to Early Eocene *S. paracarinata*. The latter species has mainly more elongation test to its width, less flaring later chambers and less curved sutures than *S. knebeli.* It was described from the Early Eocene of Egypt and UAE.

***Spiroplectinella pectinatiformis* (Balakhmatova, 1964) - Pl. 2, fig. 27**

1969 *Textularia pectinatiforma* (Balakhmatova) - Kraeva and Zernetskij, p. 28, pl.8, fig.13a, б.

2019 *Spiroplectinella pectinatiforma* (Balakhmatova) - Darakchieva et al., p.12, pl.1, fig. 8. ●

The test of this species is pyramid-shape, flattened, elliptical in cross section. The initial portion is small and unclearly planispiral, the later one is biserial consisting of numerous, narrow chambers gradually increasing in size. The periphery is with thin and narrow keel. The aperture is arch-shaped, interiomarginal. The wall is finely agglutinated with smooth surface. It is known from the upper Eocene of Turkmenistan, Moldova, and the Oligocene of Bulgaria (Darakchieva et al., 2019).

***Spiroplectinella plummerae* (Cushman, 1948) - Pl. 2, fig. 28**

1927 *Textularia carinata* d'Orbigny, var. *expansa* Plummer, p. 67, pl. 3, fig. 3.

1948 *Spiroplectammina plummerae* Cushman, p. 226, pl. 16, fig. 2. ●

1951 *Spiroplectammina plummerae* Cushman - Cushman, p. 5, pl. 1, figs. 19, 20.

1959 *Spiroplectammina expansa* (Plummer) - Öztemür, p. 4, pl. 3, fig. 2.

1982 *Ammobaculites expansus* (Plummer) - Proto Decima and Bolli, p. 116.

2017 *Spiroplectinella expansa* (Plummer) - Anan, p. 274, fig. 6. 1.

This Paleocene-Eocene subspecies of Plummer (1927) was later renamed to *S. plummerae* due to foraminiferal homonym *Spiroplectammina expansa* LeRoy, 1941 (ICZN. 2000). It has somewhat elongate test, triangular outline compressed test with sharply angular margin, chambers numerous, sutures distinct and depressed, gently curved and somewhat oblique, limbate toward the axis of the test, but tapering toward the margin, wall finely arenaceous and smoothly finished. It was recorded in the Paleocene from USA (Cushman, 1948), and Italy (Proto Decima and Bolli, 1982, p. 116), but Eocene in Turkey (Öztemür, 1959).

***Spiroplectinella praelonga* (Reuss, 1845) - Pl. 2, fig. 29**

1845 *Textularia praelonga* Reuss, p. 39, pl. 12, fig. 14.

1968 *Spiroplectammina praelonga* (Reuss) - Neagu, p. 228, text-fig. 2.19.

1981 *Spiroplectammina praelonga* (Reuss) - Morgiel and Olszewska, p. 14, pl. 4, fig. 5. ●

This species has elongate test, rhomboidal in section, small planispiral initial stage then numerous and quadrate biserial chambers alternately arranged. It was recorded from Germany, Romania (Neagu, 1968) and Poland (Morgiel and Olszewska, 1981).

***Spiroplectinella richardi* (Martin, 1943) - Pl. 2, fig. 30**

1943 *Spiroplectammina richardi* Martin, p. 104, pl. 5, fig. 3.

1951 *Spiroplectammina richardi* Martin - Israelsky, p. 13, pl. 4, figs. 1-16.●

2008 *Spiroplectammina richardi* Martin - Miranda-Martinez and Carreño, p. 100.

Test roughly triangular in side view and compressed laterally, peripheral margin sharply keeled with wide serrated flange, wall finely arenaceous with large amount of cement giving rough surface. It was recorded from USA (Israelsky, 1951) and Mexico (Miranda-Martinez and Carreño, 2008).

***Spiroplectinella rossae* (Plummer, 1933) - Pl. 2, fig. 31**

1933 *Spiroplectammina rossae* Plummer, p. 66, pl. 5, fig. 1-3.

1951 *Spiroplectammina rossae* Plummer - Cushman, p. 5, pl. 1, figs. 15, 16.●

This Paleocene species has small elongate compressed test, biserial chambers sloping from the axis on each side at an angle of about 45º and gently curved downward along the outer edge, sutural limbations strongly elevated on each side of the center, aperture a rather high arch at the base of the septal face. It is , so far, an endemic to USA.

***Spiroplectinella semicomplanata* (Carsey, 1926) - Pl. 2, fig. 32**

1926 *Textularia semicomplanata* Carsey, p. 25, pl. 3, fig. 4.

1931 *Spiroplectammina semicomplanata* Carsey - Plummer, p. 129, pl. 8, figs. 7, 8.

1946 *Spiroplectammina semicomplanata* Carsey - Cushman, p. 28, pl. 6, figs. 5-14.

1972 *Spiroplectammina semicomplanata* Carsey - Hanzlíková, p. 48, pl. 10, figs. 2-4. ●

1982 *Spiroplectammina semicomplanata* Carsey - Beckmann, p. 113, pl. 4, fig. 15.

This species differs from *S. chicoana* in being thicker more rapidly tapering and in having a more even periphery. It was recorded from USA, Czech (Hanzlíková, 1972) and Italy (Beckmann, 1982).

***Spiroplectinella sigmoidina* (Lalicker, 1935) - Pl. 2, fig. 33**

1935 *Spiroplectammina sigmoidina* Lalicker, p. 7, pl. 1, figs. 10, 11.

1968 *Spiroplectammina sigmoidina* Lalicker - Sliter, p. 46, pl. 2, fig. 12.●

Sliter (1968) noted that this species differs from *S. chicoana* by its narrower test, more regular periphery and smoother surface. It was recorded, so far, from USA and Mexico.

***Spiroplectinella subhaeringensis* (Grzybowski, 1896) - Pl. 2, fig. 34**

1896 *Textularia subhaeringensis* Grzybowski, p. 285, pl. 9, figs. 13, 16.

1975 *Vulvulina haeringensis* (Grzybowski) - Proto Decima and De Biase, p. 91, pl. 1, fig. 23.
1982 *Spiroplectammina subhaeringensis* (Grzybowski) - Beckmann, p. 113, pl. 4, fig. 16.
1983 *Spiroplectinella subhaeringensis* (Grzybowski) - Tjalsma and Lohmann, p. 20, pl. 2, fig. 3.
1995 *Spiroplectammina subhaeringensis* (Grzybowski) - Bubík, p. 87, pl. 14, figs. 8, 12.
2005 *Spiroplectammina subhaeringensis* (Grzybowski) - Sztrákos, p. 184, pl. 2, fig. 1.●
2007 *Spiroplectammina subhaeringensis* (Grzybowski) - Ozsvárt, p. 33, pl. 1, fig. 12.
2015 *Spiroplectinella subhaeringensis* (Grzybowski) - Anan, p. 245, fig. 4.12.
2019 *Spiroplectinella subhaeringensis* (Grzybowski) - Darakchieva et al., p. 13, pl.1, fig. 9.

The test length of this species is approximately equal to its width, with very small planispiral initial portion comprising three to four chambers. The late portion is biserial and consists of four to five pairs of chambers, increasing very rapidly in size. The periphery is subacute, with a very narrow keel. The wall is finely agglutinated. The aperture is interiomarginal fissure. The species was recorded from the Eocene of Central America (Tjalsma and Lohmann, 1983), France (Sztrákos, 2005), Hungary (Ozsvárt, 2007), Poland (Grzybowski, 1896; Bubík, 1995), Paleocene of UAE (Anan, 2015) and lower Oligocene of Bulgaria (Darakchieva et al., 2019).

***Spiroplectinella wilcoxensis* (Cushman and Ponton, 1932) - Pl. 2, fig. 35**

1932 *Spiroplectammina wilcoxensis* Cushman and Ponton, p. 51, pi. 7, fig. 1.
1951 *Spiroplectammina wilcoxensis* Cushman and Ponton - Cushman, p. 6, pl. 1, figs. 21-23.●
1965 *Spiroplectammina wilcoxensis* Cushman and Ponton - Pozaryska, p. 50, pl. 3, fig. 1.

Test broad, periphery subacute, chambers low and broad in the early portion, gradually and rather regularly increasing in height as added, later ones slightly! inflated; sutures slightly depressed especially in the later portion, gently curved, wall arenaceous but rather smoothly finished, aperture a low curved opening at the base of the apertural face. It was recorded from USA (Cushman, 1951) and Poland (Pozaryska, 1965).

***Spiroplectinella wrightii* (Silvestri, 1903) - Pl. 2, fig. 36**

1903 *Spiroplecta wrightii* Silvestri, p. 59, figs. 1-6.
1972 *Spiroplectinella wrightii* (Silvestri) - Kisel'man, p. 135, fig. 1.
1988 *Spiroplectinella wrightii* (Silvestri) - Loeblich and Tappan, p. 112, pl. 120, figs. 1-16.
2014 *Spiroplectinella wrightii* (Silvestri) - Spezzaferri et al., p. 55, pl. 3, fig. 6. ●

This Paleocene-Holocene species has early planispiral coil followed by biserial chambers increases rapidly in breadth, lozenge shaped in section with faint marginal keel, wall coarsely agglutinated. It was recorded from Romania (Silvestri, 1903), Russia (Kisel'man, 1972) and Norway (Spezzaferri et al., 2014).

Paleogeography

The paleogeographic maps (partly or regionally) of some authors, i. e. Mintz (1981), Rosenbaum et al. (2002) show the Tethyan realm had been connected with the Indo-Pacific Ocean from the east and Atlantic Ocean to the west via Mediterranean Sea crossing the Middle East region during the Maastrichtian-Paleogene time. The following detailed remarks can be presented:

1. Haq and Aubry (1978) noted that the North Africa and Middle East formed important parts of the Tethyan link between the Atlantic and Pacific Oceans during Paleogene.

2. Anan (1995) concluded that the Tethyan realm during the middle-late Eocene extends to the southeast and connected with the Indo- Pacific realm via seaway separating Arabia from Iran-India region.

3. Haynes and Nwabufo-Ene (1998) suggested wider Tethyan connections, as far as the Carpathian and Pakistan.

4. Rögl (1999) noted that by the end of the Eocene the Tethys Ocean had already vanished, a new Indian Ocean was born, the western end of the Tethys was reduced to a Mediterranean Sea, Europe was still an archipelago and intercontinental seas covered large areas of the European platform and of western Asia. Between the stable Eurasian platform and the relics of the western Tethys, an elongate deep basins had formed and north of India a marine connection stretched to the west Pacific.

Another remarks of the paleogeographical distribution of the faunal Tethys can be added:

1. Most of the recorded agglutinated species of the genus *Spiroplectinella* were erected from USA (15/33, about 45 %), 12 from Egypt (about 36 %), 8 from Poland (about 24 %), 6 from France and also UAE (about 18 %), 5 from Czech and Bulgaria (about 15 %), 4 species for each of Mexico, Caribbean and Italy (about 12 %).

2. The number differences of the recorded species between the different localities in the Tethys may be due to one or more parameters: the deficiency of available literatures, differences in ecological or environmental conditions (depth, salinity, water temperature, dissolved oxygen, nutrient, land barrier..) and not homogeneity in the generic or species concept according to different authors.

Paleoecology and Paleoenvironment

1. Van der Zwaan (1982) indicates that *Spiroplectinella carinata* has no tolerance for variations in oxygen content and salinity, and it is present in outer shelf (70-100) meter sediments and prefers muddy substrate by Barbin and Keller-Gninig (1991).

2. Miller *et al.* (1982) infer that certain hydrographic properties (low oxygen, high CO3, low pH, and thus more corrosive waters) favor the development of agglutinated assemblages. They also reported that the "Flysch-type Assemblage, FTA" (as described by Gradstein and Berggren, 1981) result from the exclusion of calcareous benthic foraminifera below a local CCD (Calcareous Compensation Depth). The local tectonic and sedimentological vents may have been important in the replacement of agglutinated assemblages in the Canadian margin and the North Sea.

3. Corliss (1985) postulated that the mode of life of a taxon can be deduced from the morphology of its test and the endobenthic species (e.g. *Spiroplectammina, Spiroplectinella*) live under the water/sediment interface and they burrow through the sediments, where they can tolerate less oxygenated conditions.

4. Jones (1988) noted that the FTA represents upper slope (500 m), middle slope (500-1000 m) and basin floor (1000-1500 m) in the Viking Graben in the North Sea. The FTA (e.g. *Spiroplectammina*) in the upper slope are fine to medium-grained, white in color, and relatively medium-sized. Distributional patterns of the FTA are consistent with recent observations showing a correlation of size, coarseness of test and diversity patterns with bottom energy conditions, turbidity currents and water depth.

5. Loeblich and Tappan (1989) noted that *S. dentata* (Alth) had a coarse-grained wall texture, agglutinated skeletal fragments and quartz grains ranging from 2-60 μm. Agglutinated species are more abundant and diverse at the sea floor than at a few centimeters below the surface.

6. Barbin and Keller (1991) stated that *S. carinata* is present in outer shelf (70-100) meter sediments and this species prefers muddy substrate, and the non-carinate species (S. deperdita) prefers nearshore silt and sands. These authors consider the carinate species of *Spiroplectammina* as deepest waters indicators with respect to the non-carinate ones.

7. Kuhnt and Kaminski (1993) considered some calcareous agglutinated species (e.g. *Spiroplectammina, Spiroplectinella*) are dominated by epifaunal detritus-feeders. A strong increase of this genus is observed in the marly upper portion of the K/T boundary clay of the Basque Basin in Northern Spain.

8. Bubík (1995) also considered some genera (e.g. *Spiroplectammina, Spiroplectinella*) belong to those of calcareous agglutinated foraminifers with cement.

9. Orabi (1995) noted that the species of the genus *Spiroplectinella* belong to the calcareous agglutinated group which composed of calcareous grains with different sizes and cemented by calcareous material.

10. Miranda-Martinez and Carreño (2008) noted that *S. richardi* has upper depth limits in the outer shelf biofacies, the continental slope environment at an upper bathyal water depth of 500 m, of the Early Eocene rocks, Tepetate Formation of Mexico.

11. Hewaidy et al. (2014) noted that the calcareous agglutinated foraminiferal genus *Spiroplectinella* is interpreted as of shelf environment.

12. Hewaidy et al. (2019) noted that *Spiroplectinella* biofacies are restricted to outer neritic-upper bathyal environment.

13. Bejaoui et al. (2019) considered some agglutinated genera (e.g. *Spiroplectammina, Spiroplectinella*) belongs to characteristics bathyal-abyssal environment, high terrigenous sedimentation rate and associated organic flux.

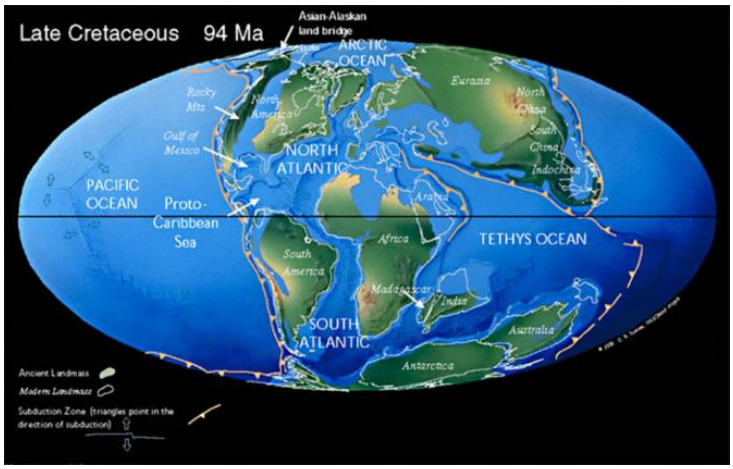


Fig. 1: The paleogeographic distribution of the Tethys in the Late Cretaceous (about 94 Ma).

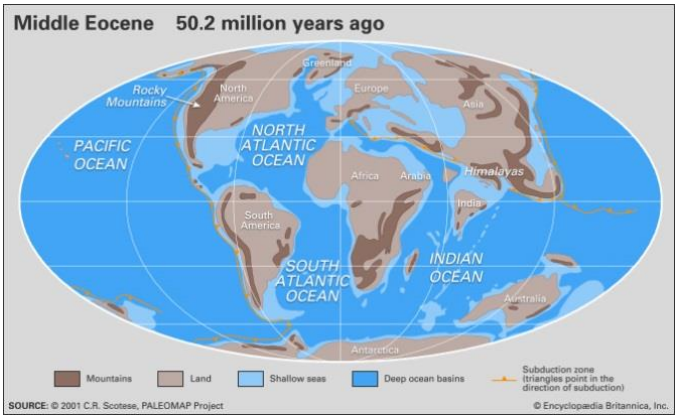


Fig. 2: The paleogeographic distribution of the Tethys in the Middle Eocene (about 50.2 Ma).

Fig. 3: The paleogeographic distribution of different species of the genus *Spiroplectinella* in Europe (France, Italy, Poland, Austria, Slovenia, Hungaria, Romania), Northeast Africa (Egypt) and South Asia (UAE, Iran, Pakistan).

Fig. 4: The paleogeographic distribution of different species of the genus *Spiroplectinella* in North America (USA, Mexico) and South America (Trinidad, Venezuela, Ecuador, Brazil, Argentina, Chile).

Table 1: The distribution of the benthic foraminiferal species of the genus Spiroplectinella in and some Tethyan localities. 1: USA, 2: Mexico, 3: Caribbean, 4: South America, 5: Spain, 6: France, 7: Poland, 8: Germany, 9: Italy, 10: Czech, 11: Hungary: 12: Slovenia, 13: Croatia, 14: Romania, 15: Bulgaria, 16: Turkey, 17: Tunisia, 18: Egypt, 19: Iraq, 20: Jordan, 21: UAE, 22: Iran, 23: Pakistan (Θ=illustrated species, x=recorded species).

Sp. no	Benthic foraminiferal species of the genus *Spiroplectinella*	Tethyan localities																						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	*adamsi*	x			x															x		Θ		
2	*baudouiniana*						x	Θ																
3	*carinata*					x	x	x								Θ			x			x	x	
4	*chicoana*	x	x	Θ			x	x																
5	*costata*							Θ			x													
6	*cretosa*										Θ													
7	*dalmatina*									x				Θ										
8	*dentata*	x		Θ			x	x		x	x								x	x			x	
9	*deperdita*						x					x				Θ								
10	*desertorum*																		Θ					
11	*elongata*	x																						Θ
12	*esnaensis*						x											x	Θ				x	
13	*excolata*	x		Θ						x						x								
14	*hamdani*																		x			Θ		
15	*henryi*																		Θ					
16	*israelski*	x				x				Θ														
17	*jarvisi*	x		Θ	x																			
18	*knebeli*																	x	Θ		x	x		
19	*laevis*	x	x			x			x		x								Θ	x				
20	*longa*																		Θ					
21	*nuttalli*				x														x			Θ		
22	*paleocenica*	Θ																						
23	*paracarinata*																		Θ			x		
24	*pectinatiforma*															Θ								
25	*plummerae*	Θ								x							x							
26	*praelonga*							Θ	x						x									
27	*richardi*	Θ	x																					
28	*rossae*	Θ																						
29	*semicomplanata*	x								x	Θ													
30	*sigmoidina*	x	Θ																					
31	*subhaeringensis*						Θ	x				x				x								
32	*wilcoxensis*	Θ						x																
33	*wrightii*														Θ									

Plate 1

1. S*piroplectinella* Kisel'man (1972), **2**. *Spiroplectammina* Cushman (1927), **3**. *Bolivinopsis* Yakovlev (1891), **4**. *Spiroplectinella adamsi* (Lalicker, 1935), **5**. *S. baudouiniana* (d'Orbigny, 1840), **6**. *S. carinata* (d'Orbigny, 1846), **7**. *S. chicoana* (Lalicker, 1935), **8**. *S. costata* (Huss, 1966), **9**. *Spiroplectinella cretosa* (Cushman, 1932), **10**. *S. dalmatina* (de Witt Puyt, 1941), **11**. *Spiroplectinella dentata* (Alth, 1850), **12**. *S. deperdita* (d'Orbigny, 1846), 13. *S. desertorum* (LeRoy, 1953), 14. *S. elongata* (Davis, 1941), **15**. *S. esnaensis* (LeRoy, 1953), **16**. *S. excolata* (Cushman, 1926).

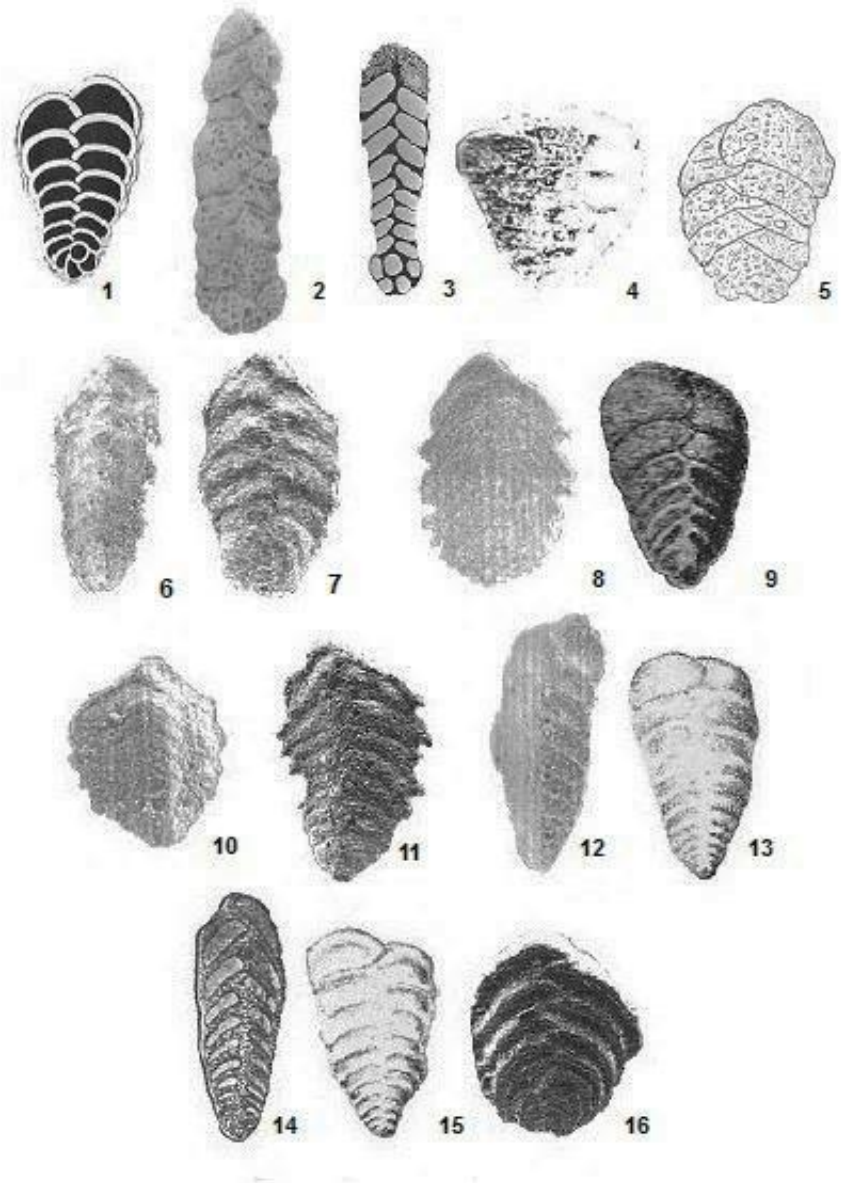
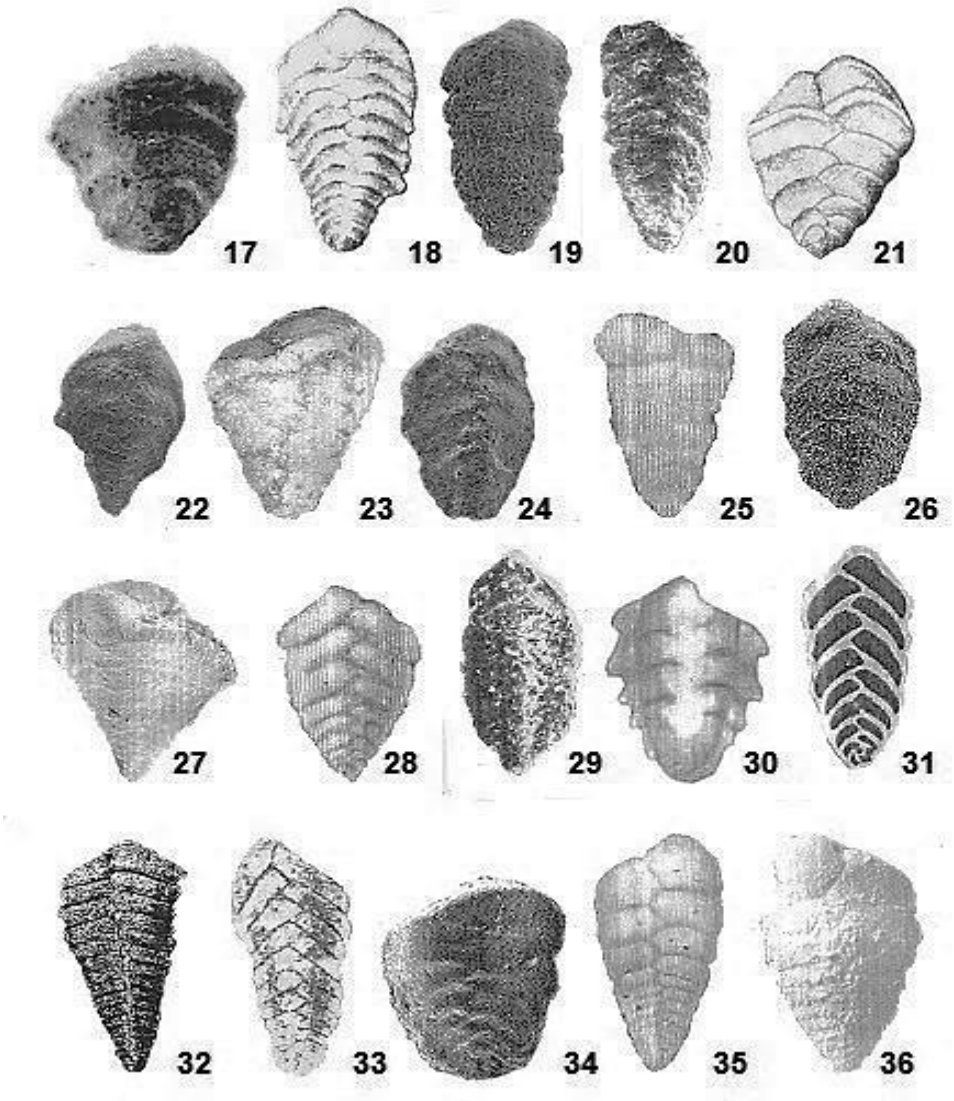


Plate 2

17. *Spiroplectinella hamdani* (Anan, 1993), **18**. *S. henryi* (LeRoy, 1953), **19**. *S. israelskyi* (Hillebrandt, 1962), **20**. *S. jarvisi* (Cushman, 1939), **21**. *S. knebeli* (LeRoy, 1953), **22**. *S. laevis* (Roemer, 1841), **23**. *S. longa* (Said and Kenawy, 1956), **24**. *S. nuttalli* (Lalicker, 1935)**, 25**. *S. paleocenica* (Cushman, 1947), **26**. *S. paracarinata* (Said and Kenawy, 1956), **27**. *S. pectinatiformis* (Balakhmatova, 1965), **28**. *S. plummerae* (Cushman, 1948), **29**. *S. praelonga* (Reuss, 1845), **30**. *S. richardi* (Martin, 1943), **31**. *S. rossae* (Plummer, 1933), **32**. *S. semicomplanata* (Carsey, 1926), **33**. *S. sigmoidina* (Lalicker, 1935), **34**. *S. subhaeringensis* (Grzybowski, 1896), **35**. *S. wilcoxensis* (Cushman and Ponton, 1932), **36**. *S. wrightii* (Silvestri, 1903).



Conclusions

The analysis of paleontology, stratigraphy and paleogeographic remarks are presented for 33 diagnostic agglutinated foraminiferal species of the genus Spiroplectinella described from the Late Cretaceous-Paleogene and Neogene rocks from many localities of the Tethys.

1. The paleogeography distribution of these taxa in different Tethyan localities throughout the Maastrichtian-Paleogene time are from Atlantic to Pacific via Mediterranean and Indian Ocean, in North America (USA, Mexico), Central America (Caribbean), South Atlantic (Brazil, Argentina, Chile Venezuela, Ecuador), Europe (North Sea, Norway, Spain, France, Poland, Norway, Netherland, Austria, Italy, Czech, Hungary, Croatia, Slovenia, Romania, Bulgaria, Moravia, Croatia, Russia, Ukraine, Turkmenistan), North Africa (Tunisia, Libya, Egypt), Southwest Asia (Turkey, Iraq, Jordan, UAE, Iran), and Indian Ocean (Pakistan, Australia-Antarctic Basin).

2. The high diversity of the identified species is recorded from North America (USA) followed by North Africa (Egypt), Europe (Poland and France) and southwest Asia (UAE).

3. Some species has wide geographic distribution, like: *Spiroplectinella dentata* (9 localities), *S. laevis* (8), *S. carinata* (7), *S. chicoana* (5), 4 localities for some species: *S. esnaensis, S. excolata, S. knebeli, S. subhaeringensis*. The other species were existed in three or two localities.

4. The unclosed record number of these species in different localities of the Tethys may due to the lack of detailed study for these and other localities, land barriers and/or different paleoenvironmental conditions (temperature, depth, dissolved oxygen, salinity, etc..).

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