

RESEARCH ARTICLE

TETHYAN BARTONIAN-PRIABONIAN DIAGNOSTIC BENTHIC FORAMINIFERA
PART II: SUBORDER MILIOLINA

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ARTICLE DETAILS

Article History:

Received 07 April 2024
Revised 14 May 2024
Accepted 18 June 2024
Available online 25 June 2024

ABSTRACT

The modern taxonomical consideration is used for the studied fifty two small porcelaneous benthic foraminiferal species of the Suborder Miliolina throughout the Bartonian-Priabonian belonging to nine genera from seventeen countries in the Northern Tethys (USA, France, Belgium, Germany, Austria, Italy, Hungaria, Slovenia, Turkey) and Southern Tethys (Ecuador, Chile, Argentina, Libya, Egypt, UAE, Pakistan, India). Two of the recorded species are treated here as new: *Massilina saidi* Anan, n. sp. and *Quinqueloculina alaghai* Anan, n. sp. Some of the recorded species are distributed outside its original description in neighbor localities or even far from it, but others are endemic to their original description. The recorded foraminiferal assemblage indicates an open marine environment, and represents favor warm, marginal to deep sheltered environments.

KEYWORDS

Miliolina, Benthic Foraminifera, Bartonian, Priabonian, Northern Tethys, Southern Tethys.

1. INTRODUCTION

Benthic foraminifera are an important source of information on past environmental variability. In this study, an attempt has been made to bring together the fifty-two Bartonian-Priabonian small porcelaneous species from seventeen countries in the Northern and Southern Tethys (Figure1).

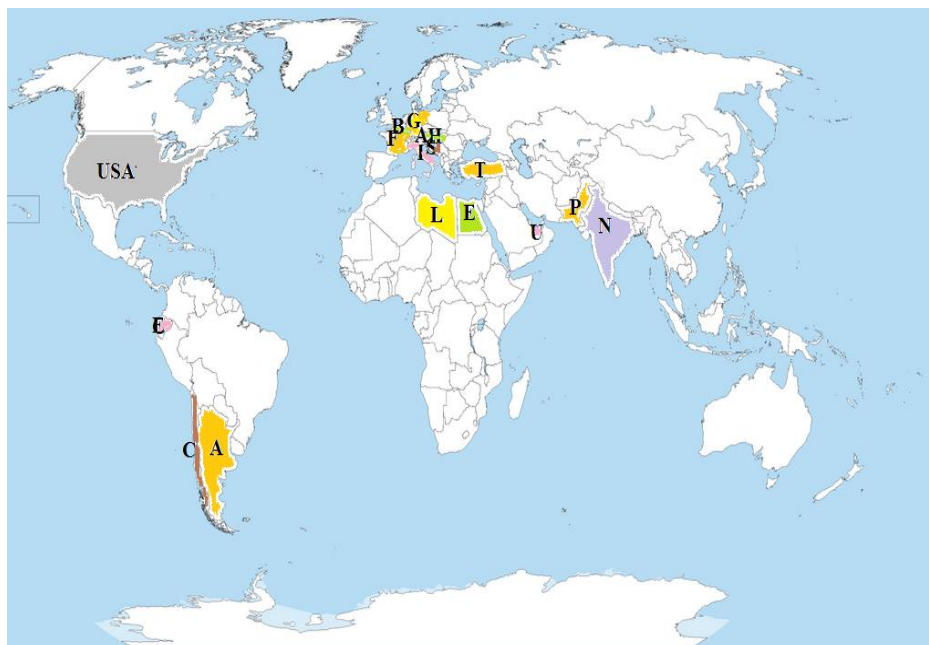


Figure 1: Geographic distribution of the identified small porcelaneous benthic foraminiferal species in the Northern and Southern Tethys: USA=United States of America, E=Ecuador, C=Chile, A=Argentina, France, B=Belgium, G=Germany, A=Austria, I=Italy, H=Hungaria, S=Slovenia, T=Turkey, L=Libya, Y=Egypt, U=United Arab Emirates, P=Pakistan, N=India.

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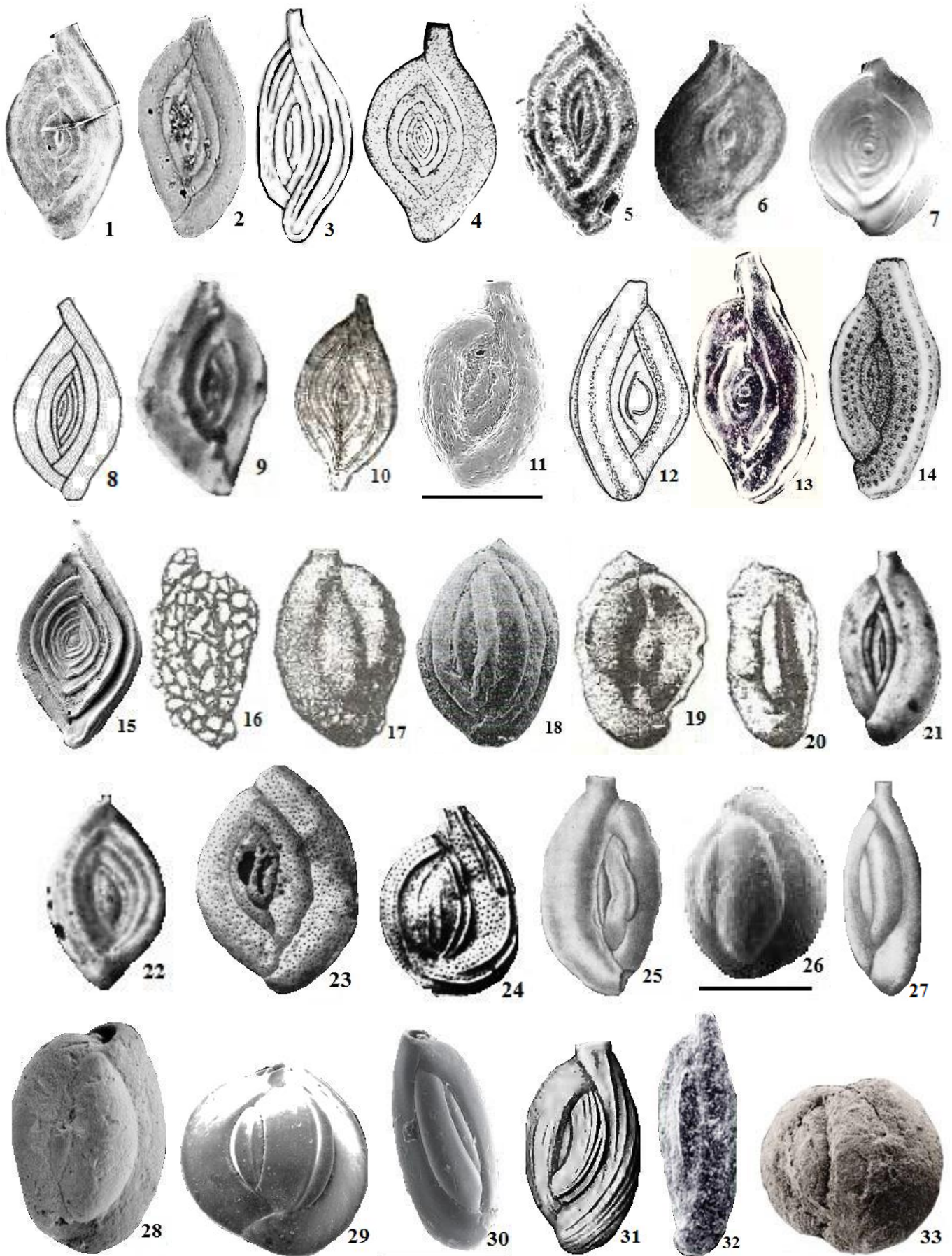
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2. MATERIAL OF STUDY

The fifty-two Bartonian-Priabonian Miliolid species from seventeen countries in the Northern and Southern Tethys made it possible to elucidate them with modern taxonomical consideration. A taxonomic revision of two species of them are re-described which considered here as a new: *Massilina saidi* and *Quinqueloculina alaghai*.

2.1 Systematic Paleontology

The taxonomic considerations of Loeblich and Tappan for the Bartonian-Priabonian fifty-two small porcelaneous benthic foraminiferal species in the Northern and Southern Tethys is followed here. The identified species are illustrated in Plate 1 (Loeblich and Tappan, 1988).



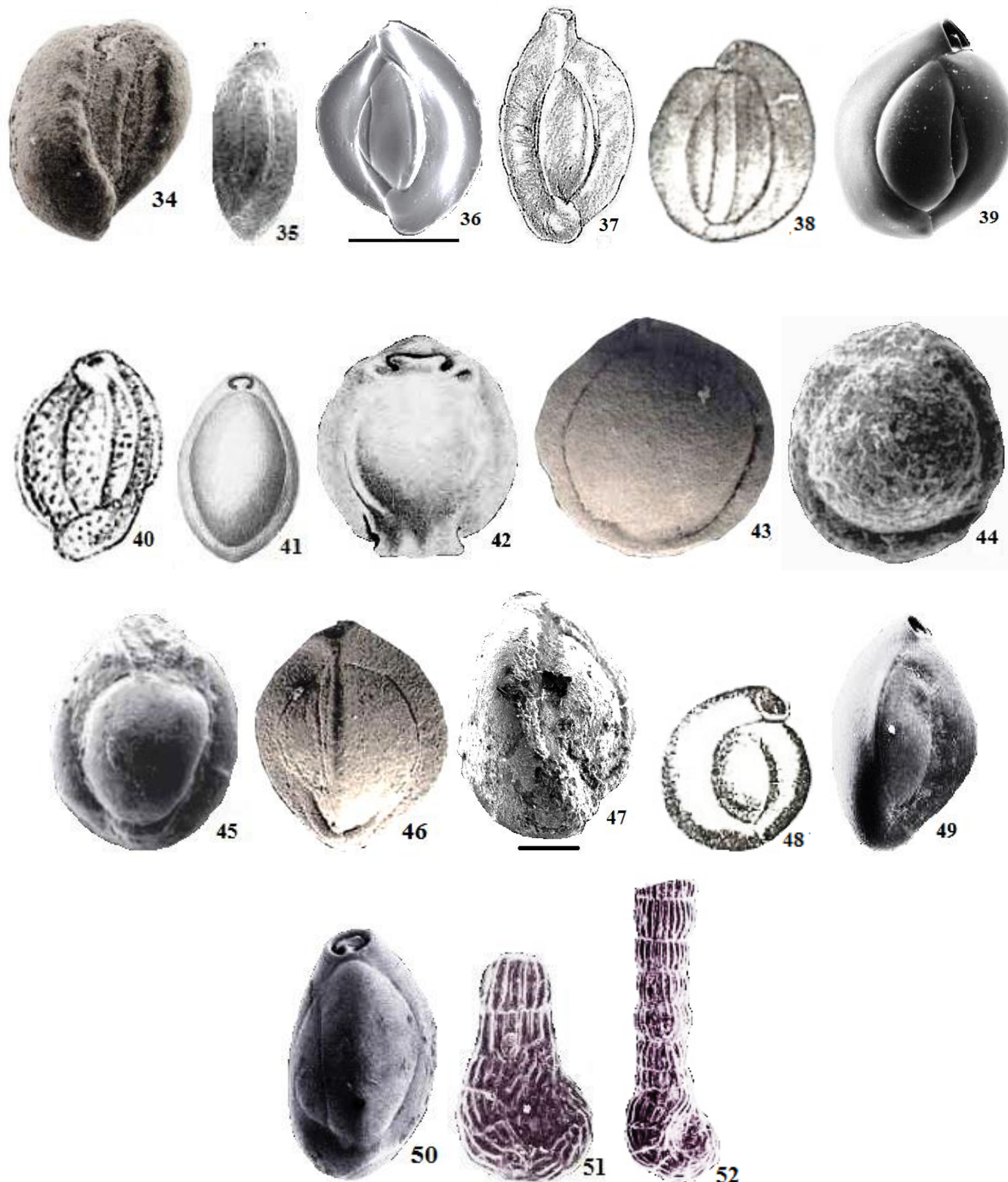


Plate 1: Fig. 1. *Spiroloculina angulosa* Terquem (1878), 2. *S. argentinica* Anan, (2024), 3. *S. bicarinata* d'Orbigny (1826), 4. *S. canaliculata* d'Orbigny (1846), 5. *S. depressa* d'Orbigny (1826), 6. *S. dilatata* d'Orbigny (1846), 7. *S. excavata* d'Orbigny (1846), 8. *S. foliacea* Schwager (1878), 9. *S. grateloupi* d'Orbigny (1826), 10. *S. haquei* Anan (2021a), 11. *S. inflata* Terquem (1882), 12. *S. morelleti* Le Calvez (1953), 13. *S. ornata* d'Orbigny (1839), 14. *S. pertusa* Terquem (1882), 15. *S. tenuiseptata* Brady (1884), 16. *Agglutinella reinemundi* (Haque, 1960), 17. *A. sori* (Haque, 1960), 18. *Ammomassilina misrensis* Anan (2021b), 19. *Dentostomina ammobicarinata* (Haque, 1960), 20. *D. ammoirregularis* (Haque, 1960), 21. *Massilina cookei* Cushman (1935), 22. *M. decorata* Cushman (1922), 23. *M. jacksonensis* Cushman (1933), 24. *M. punctatocostata* Cushman (1933), 25. *Massilina saidi* Anan, n. sp., 26. *Quinqueloculina alaghai* Anan, n. sp., 27. *Q. anguina* Terquem (1878), 28. *Q. argentinica* Anan (2024), 29. *Q. bicarinata* d'Orbigny (1878), 30. *Q. busciana* d'Orbigny (1839), 31. *Q. costata* d'Orbigny (1826), 32. *Q. depressa* d'Orbigny (1852), 33. *Q. hauerina* d'Orbigny (1846), 34. *Q. impressa* Reuss (1851), 35. *Q. laevigata* d'Orbigny (1826), 36. *Q. lamarckiana* d'Orbigny (1839), 37. *Q. longirostra* d'Orbigny (1826), 38. *Q. pseudosimplex* (Haque, 1960), 39. *Q. seminulum* (Linné, 1758), 40. *Q. tessellata* Cushman (1922), 41. *Pyrgo elongata* (d'Orbigny, 1826), 42. *P. depressa* (d'Orbigny, 1826), 43. *P. pseudoinornata* Cushman & Stainforth (1951), 44. *P. simplex* (d'Orbigny, 1846), 45. *P. subsphaerica* (d'Orbigny, 1839), 46. *Triloculina angularis* d'Orbigny (1850), 47. *T. gibba* d'Orbigny (1846), 48. *T. psudoenoplostoma* Haque (1960), 49. *T. tricarinata* d'Orbigny (1826), 50. *T. trigonula* (Lamarck, 1804), 51. *Spirolina mariei* Le Calvez (1952), 52. *S. pedum* d'Orbigny (1826).

Order Foraminiferida Eichwald, 1830

Suborder Miliolina Delage & Hérouard, 1896

1. *Spiroloculina angulosa* Terquem, 1878, p. 53, pl. 5, fig. 7. This species is distinguished by fusiform biconcave test, angular periphery, aperture is developed on a short neck. France, Turkey.
2. *Spiroloculina argentinica* Anan, 2024, p. 27, pl. 1, fig. 5. Argentina.
3. *Spiroloculina bicarinata* d'Orbigny, 1826, p. 302, no. 35. France.
4. *Spiroloculina canaliculata* d'Orbigny, 1846, p. 269, pl. 16, figs. 10-12. France, Belgium, Austria, Egypt, UAE.
5. *Spiroloculina depressa* d'Orbigny, 1826, p. 298. This species is distinguished by its elliptical test and slightly longer than width. It differs from *S. angulosa* by having shorter neck. France, Egypt, UAE.
6. *Spiroloculina dilatata* d'Orbigny, 1846, p. 271, pl. 16, figs. 16-18. France.
7. *Spiroloculina excavata* d'Orbigny, 1846, p. 271, pl. 16, figs. 19-21. It has subelliptical biconcave test and short neck. France.
8. *Spiroloculina foliacea* Schwager, 1878, p. 529, pl. 1, fig. 20. Italy.
9. *Spiroloculina grateloupi* d'Orbigny, 1826, p. 298. France, USA.
10. *Spiroloculina haquei* Anan, 2021a, p. 44, pl. 1, fig. 1. Pakistan.
11. *Spiroloculina inflata* Terquem, 1882, p. 193. France, India.
12. *Spiroloculina morelleti* Le Calvez (1953). France.
13. *Spiroloculina ornata* d'Orbigny, 1839, p. 167, pl. 12, fig. 7. It is characterized by its elongate, compressed and irregular outline test, bicarinate periphery, and aperture is developed on a relatively long neck. France.
14. *Spiroloculina pertusa* Terquem, 1882, p. 160, pl. 16, fig. 27. France.
15. *Spiroloculina tenuiseptata* Brady, 1884, p. 153, pl. 10, fig. 5. It has flattened fusiform and rectangular test. USA, Turkey.
16. *Agglutinella reinemundi* (Haque, 1960), p. 19, pl. 2, fig. 5). Pakistan.
17. *Agglutinella sori* (Haque, 1960), p. 20, pl. 5, fig. 9). Pakistan.
18. *Ammomassilina misrensis* Anan, 2021b, p. 88, pl. 1, fig. 22. Egypt.
19. *Dentostomina ammobicarinata* (Haque, 1960) p. 54, pl. 6, fig. 6. This species has quinqueloculine arrangement test with crenulated margin, agglutinated quartz grains outer layer, terminal circular aperture with long narrow bifid tooth. Pakistan.
20. *Dentostomina ammoirregularis* (Haque, 1960), p. 54, pl. 6, fig. 4. Pakistan.
21. *Massilina cookei* Cushman, 1935, p. 13, pl. 3, fig. 17. USA.
22. *Massilina decorata* Cushman (1922), p. 143, pl. 34, fig. 7. USA.
23. *Massilina jacksonensis* Cushman, 1933, p. 2, pl. 1, fig. 4. USA.
24. *Massilina punctatocostata* Cushman, 1933, p. 3, pl. 1, figs. 5, 6. USA.
25. *Massilina saidi* Anan, n. sp. (= *Massilina* sp.? , Cushman, 1935, p. 14, pl. 4, figs. 11-13).

Holotype: Plate 1, Figure 25.

Etymology: after the late Prof. Said Abdelwahad, Al Azhar University-Gaza, Palestine.

Stratigraphic level: Priabonian, from a depth of 400 feet in Ohio and Red River well 2, Tyler County, Texas, USA.

Diagnosis: This has a fairly large test, periphery of the chambers keeled, apertural cylindrical neck with a distinct lip.

Remarks: This species is characterized by its keeled periphery, and cylindrical neck aperture.

26. *Quinqueloculina alaghai* Anan, n. sp. (= *Quinqueloculina* sp. 2, Ozsvárt, 2007, p. 42, pl. 3, fig. 14).

Holotype: Plate 1, Figure 26.

Etymology: after Prof M.R. Alagha, Islamic University-Gaza, Palestine.

Stratigraphic level: Bartonian-Priabonian.

Diagnosis: Test large oval in lateral view, each chamber comprising one and half coil and overlapped by subsequent chambers, wall porcellaneous smooth, sutures depressed, aperture terminal.

Remarks: This species is characterized by each chamber is overlapped by subsequent chambers.

27. *Quinqueloculina anguina* Terquem, 1878, p. 78, pl. 9 (14), fig. 20. France.
28. *Quinqueloculina argentinica* Anan, 2024, p. 27, pl. 1, fig. 6. Argentina.
29. *Quinqueloculina bicarinata* d'Orbigny, in Terquem, 1878, p. 68, pl. 7, fig. 10. France, Belgium.
30. *Quinqueloculina busciana* d'Orbigny, 1839, p. 191, pl. 11, figs. 22-24. France, Hungary.
31. *Quinqueloculina costata* d'Orbigny, 1826, p. 301, no. 3. France, USA.
32. *Quinqueloculina depressa* d'Orbigny, 1852, p. 302, no. 38. France, Belgium.
33. *Quinqueloculina hauerina* d'Orbigny, 1846, p. 286, pl. 17, figs. 25-27. France, Egypt, UAE.
34. *Quinqueloculina impressa* Reuss, 1851, p. 87, pl. 7, fig. 59. Germany, France, Egypt, UAE.
35. *Quinqueloculina laevigata* d'Orbigny, 1826, p. 301, no. 6. France, USA, Libya.
36. *Quinqueloculina lamarckiana* d'Orbigny, 1839, p. 189, pl. 11, figs. 14-15. France, India.
37. *Quinqueloculina longirostra* d'Orbigny, 1826, p. 303, no. 46. France, USA.
38. *Quinqueloculina pseudosimplex* (Haque, 1960). Pakistan.
39. *Quinqueloculina seminulum* (Linné, 1758). France, Belgium, Egypt, UAE.
40. *Quinqueloculina tessellata* Cushman, 1922, p. 142, pl. 33, fig. 8. USA.
41. *Pyrgo elongata* (d'Orbigny, 1826), p. 298, no. 4. France.
42. *Pyrgo depressa* (d'Orbigny, 1826), p. 298, no. 91. France, Chile.
43. *Pyrgo pseudoinornata* Cushman & Stainforth, 1951, p. 145, pl. 25, fig. 39. Ecuador, UAE.
44. *Pyrgo simplex* (d'Orbigny, 1846), p. 264, pl. 15, figs. 25-27. France, Slovenia.
45. *Pyrgo subsphaerica* (d'Orbigny, 1839), p. 162, pl. 8, figs. 25-27. France, Slovenia.
46. *Triloculina angularis* d'Orbigny, 1850, in Fornasini, 1905, pl. 1, fig. 2. France, Egypt, UAE.
47. *Triloculina gibba* d'Orbigny, 1846, p. 274, pl. 16, figs. 22-24. France, Belgium, Egypt, UAE.
48. *Triloculina psudoenoplostoma* Haque, 1960, Pakistan.
49. *Triloculina tricarinata* d'Orbigny, 1826, p. 299, pl. 1, fig. 8. France, Egypt.
50. *Triloculina trigonula* (Lamarck, 1804), in d'Orbigny, 1826, pl. 16, figs. 5-9. France.
51. *Spirolina mariei* Le Calvez, 1952, p. 25, pl. 2, figs. 17-18. France, Hungary.
52. *Spirolina pedum* d'Orbigny, 1826, p. 121, pl. 1, figs. 20-24. France, Hungary.

3. PALEOGEOGRAPHY

According to some authors, the paleogeographic maps proved that the Tethyan Realm had been connected the Atlantic Ocean from the west to Indo-Pacific Ocean to the east, via the Mediterranean Sea (Figure 2) (i. e. Solakius et al., 1990; Abed, 2013).



Figure 2: The paleogeographic map of the Terminal Cretaceous showing some Northern and Southern Tethyan localities (after Solakius et al., 1990).

Accordingly, the following remarks can be added (Table 1):

32 of the identified species were recorded from France, 11 from USA, 9 from Egypt, while 7 from each UAE and Pakistan.

Spiroloculina canaliculata were recorded from five countries: France, Belgium, Austria, Egypt, UAE.

Quinqueloculina impressa were recorded from four countries Germany, France, Egypt and UAE, and *Q. seminulum* from France, Belgium, Egypt and UAE, while *Triloculina gibba* from France, Belgium, Egypt and UAE.

Quinqueloculina hauerina from three countries France, Egypt and UAE, and *Q. laevigata* from France, USA and Libya, while *Triloculina angularis* France, Egypt and UAE.

Spiroloculina grateloupi, *S. inflata*, *S. tenuiseptata*, *Quinqueloculina bicarinata*, *Q. busciana*, *Q. depressa*, *Q. lamarckiana*, *Q. longirostra*, *Pergo depressa*, *P. simplex*, *P. subsphaerica*, *Triloculina tricarinata*, *Spirolina mariei*, *S. pedum* are recorded, so far, only from two countries.

The other species are endemic, so far, to their original description: *Spiroloculina argentinica*, *S. bicarinata*, *S. dilatata*, *S. excavata*, *S. foliacea*, *S. haquei*, *S. morelleti*, *S. ornata*, *S. pertusa*, *Agglutinella reinemundi*, *A. sori*, *Ammomassilina misrensis*, *Dentostomina ammobicarinata*, *D. ammoirregularis*, *Massilina cookei*, *M. decorata*, *M. jacksonensis*, *M. punctatocosta*, *M. saidi*, *Quinqueloculina anguina*, *Q. argentinica*, *Q. pseudosimplex*, *Q. tessellata*, *Pyrgo elongata*, *Triloculina pseudoenoplostoma* and *T. trigonula*.

Table 1: The distribution of the Bartonian-Priabonian small porcelaneous benthic foraminiferal species in Some Tethyan Localities. US (USA), EC (Ecuador), CH (Chile), AG (Argentina), FN (France), BG (Belgium), GM (Germany), AS (Austria), HG (Hungaria), SV (Slovenia), IT (Italy), TK (Turkey), LB (Libya), ET (Egypt), UA (United Arab Emirates), PN (Pakistan), IN (India). X=recorded.

Sp. No.	Bartonian-Priabonian Small porcelaneous species		US	EC	CH	AG	FN	BG	AS	GM	HG	SV	IT	TK	LB	ET	UA	PN	IN
	Genus	species																	
1	<i>Spiroloculina</i>	<i>angulosa</i>					x												
2		<i>argentinica</i>				x													
3		<i>bicarinata</i>					x												
4		<i>canaliculata</i>					x	x	x							x	x		
5		<i>depressa</i>					x									x	x		
6		<i>dilatata</i>					x												
7		<i>excavata</i>					x												
8		<i>foliacea</i>												x					
9		<i>grateloupi</i>	x				x												
10		<i>haquei</i>																	x
11		<i>inflata</i>					x												x
12		<i>morelleti</i>					x												
13		<i>ornata</i>					x												
14		<i>pertusa</i>					x												
15		<i>tenuiseptata</i>	x																x
16	<i>Agglutinella</i>	<i>reinemundi</i>																	x
17		<i>sori</i>																	x
18	<i>Ammomassilina</i>	<i>misrensis</i>														x			
19	<i>Dentostomina</i>	<i>ammobicarin.</i>																	x
20		<i>ammoirregul.</i>																	x
21	<i>Massilina</i>	<i>cookei</i>	x																
22		<i>decorata</i>	x																
23		<i>jacksonensis</i>	x																
24		<i>punctatocosta.</i>	x																
25		<i>saidi</i>	x																
26	<i>Quinqueloculina</i>	<i>alaghai</i>									x								
27		<i>anguina</i>					x												
28		<i>argentinica</i>				x													
29		<i>bicarinata</i>					x	x											
30		<i>busciana</i>					x				x								

Table 1 (Cont.): The distribution of the Bartonian-Priabonian small porcelaneous benthic foraminiferal species in Some Tethyan Localities. US (USA), EC (Ecuador), CH (Chile), AG (Argentina), FN (France), BG (Belgium), GM (Germany), AS (Austria), HG (Hungaria), SV (Slovenia), IT (Italy), TK (Turkey), LB (Libya), ET (Egypt), UA (United Arab Emirates), PN (Pakistan), IN (India). X=recorded.

Sp. No.	Bartonian-Priabonian Small porcelaneous species		US	EC	CH	AG	FN	BG	AS	GM	HG	SV	IT	TK	LB	ET	UA	PN	IN
	Genus	species																	
31		<i>costata</i>	x				x												
32		<i>depressa</i>					x	x											
33		<i>hauerina</i>					x									x	x		
34		<i>impressa</i>					x	x								x	x		
35		<i>laevigata</i>	x				x								x				
36		<i>lamarckiana</i>					x												x
37		<i>longirostra</i>	x				x												
38		<i>pseudosimplex</i>																	x
39		<i>seminulum</i>					x	x								x	x		
40		<i>tessellata</i>	x																
41	<i>Pyrgo</i>	<i>elongata</i>					x												
42		<i>depressa</i>			x		x												
43		<i>pseudoinorna.</i>		x															x
44		<i>simplex</i>					x					x							
45		<i>subsphaerica</i>					x					x							
46	<i>Triloculina</i>	<i>angularis</i>					x									x	x		
47		<i>gibba</i>					x	x								x	x		
48		<i>pseudoenoplos.</i>																	x
49		<i>tricarinata</i>					x									x			
50		<i>trigonula</i>					x												
51	<i>Spirolina</i>	<i>mariei</i>					x				x								
52		<i>pedum</i>					x				x								

4. PALEOENVIRONMENTS

The porcelaneous foraminiferal assemblage indicates an open marine environment, which represents favor warm, marginal to deep sheltered environments, and some are tolerant of hyposalinity or hypersalinity as

well as normal marine salinity. The current activity not only transported allochthonous taxa, but also brought in refractory organic matter to the seafloor, which were in turn affected by sedimentary and ultimately by climatic factors (Figure 3).

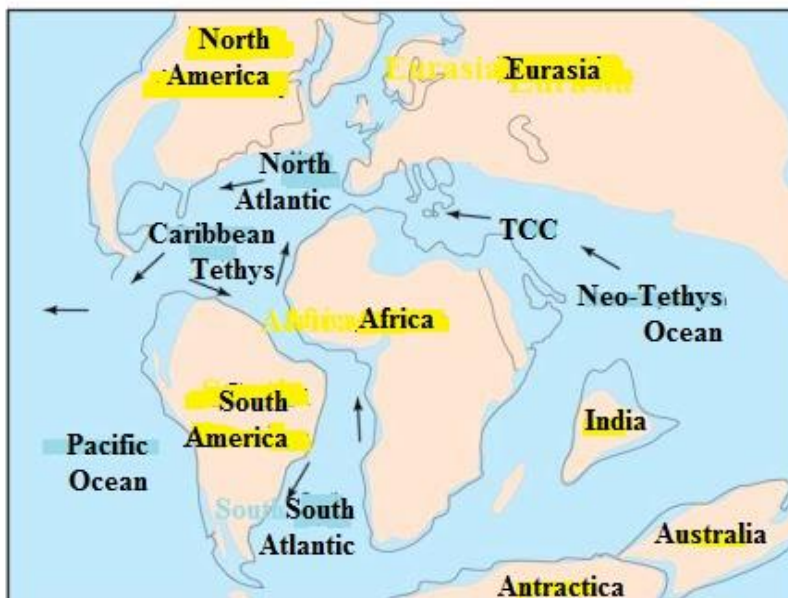


Figure 3: The Maastrichtian-Paleogene Neo-Tethys Ocean showing the flow direction of the Tethyan Circumglobal Current (TCC) from east to west (abed, 2013).

ACKNOWLEDGMENTS

The author acknowledge the support the editor of the Earth Sciences Malaysia (ESMY). Thanks are also extended to my daughter Dr. Huda Anan for the development of the figures, table and plate.

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