

## 20. OPAL PHYTOPLANKTON IN DSDP LEG 49 SAMPLES

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Sites 407 through 410 were investigated for their opal phytoplankton remains (Figure 1). Samples were prepared according to previously outlined procedures (Schrader and Fenner, 1976), and slides prepared after the standard method described in Schrader (1974). Each slide ( $18 \times 18$  mm<sup>2</sup>) represented approximately 1/200 part of the original sample split. In order to present information about diatom content of individual samples, randomly distributed microscopic fields ( $15 \times 10^4 \mu\text{m}^2$ ) were laid over the slide; each diatom, whole or fragmented, was counted as one unit, and mean values of five counts are tabulated in Tables 1 through 4.

This is intended as an initial study, not a detailed diatom study on these samples, so no detailed taxonomy or detailed information on the various biostratigraphic and paleoecologic aspects are presented. Further studies, specifically on the occurrence of Pliocene/Pleistocene diatoms, on *Denticula seminae*, *Rhizosolenia curvirostris*/*R. barboi*, and on the occurrence and causes, in

both the Norwegian Sea and the North Atlantic, of lower to middle Miocene sediments rich in siliceous material, will allow interpretation of oceanographic conditions during the early to middle Miocene.

Biostratigraphic interpretations are based on the ranges of specific species, as outlined in Burckle (1972), Schrader and Fenner (1976), and other pertinent literature (for more information see Koizumi, 1977). Since no detailed low- and high-latitude Atlantic diatom biostratigraphy has been compiled, Sites 408 and 407 might be a useful link to combine the high-latitude Norwegian Sea biostratigraphic scheme (Schrader and Fenner, 1976) with a low-latitude zonation.

### SITE 407

Pleistocene assemblages with *Rhizosolenia curvirostris* well to moderately well preserved occur from Cores 1 through Sample 3-1, 30 cm. Pliocene assemblages with common *Coscinodiscus marginatus*, *Rhizosolenia barboi*, *Thalassionema nitzschioides*, and *Thalassiothrix longissima* are present in Cores 4 through 14. Since the interval between Cores 14 and 19 contains no well-preserved opal phytoplankton assemblages, the Miocene/Pliocene boundary cannot be defined. Core 20 contains a well-preserved middle Miocene diatom assemblage. The middle/lower Miocene boundary cannot be defined. Cores 29 through 30 are tentatively placed in the lower Miocene.

### SITE 408

Poorly preserved to well-preserved Pleistocene diatom assemblages occur in Samples 408-1-1, 66 cm to 408-2-4, 133 cm, and contain abundant *Thalassiothrix longissima*, *Thalassionema nitzschioides*, *Chaetoceros* bristles and spores, *Actinocyclus curvatulus*, and *Thalassiosira grvida*. *Rhizosolenia barboi* is present in Sample 408-3-3, 82 cm, together with *Nitzschia fossilis*, and places Samples 408-3-3, 82 cm to 408-16-1, 136 cm in the Pliocene. The Pliocene/Miocene boundary may occur between Samples 408-16-1, 136 cm and 408-19-6, 60 cm. *Thalassionema nitzschioides*, *Thalassiothrix longissima*, and *Coscinodiscus marginatus* are among the commoner species, in addition to such indicator species as *Cosmidiscus insignis*, *Rhizosolenia barboi*, *Nitzschia fossilis*, *N. reinholdii*, and *Thalassiosira oestrupii*. Upper through middle Miocene species occurring in Samples 408-19-6, 69 cm through 408-30-1, 34 cm include *Denticula hustedtii*, *Mediaria splendida*, *Coscinodiscus yabei*, and associate plicate species, *Goniothecium tenue*, *Actinocyclus ingens*, *Denticula nicobarica*, *D. punctata*, *D. lauta*, *Macrora stella*, and *Denticula dimorpha*. The middle/lower Miocene boundary is tentatively placed in Sample 408-30-1, 34 cm;

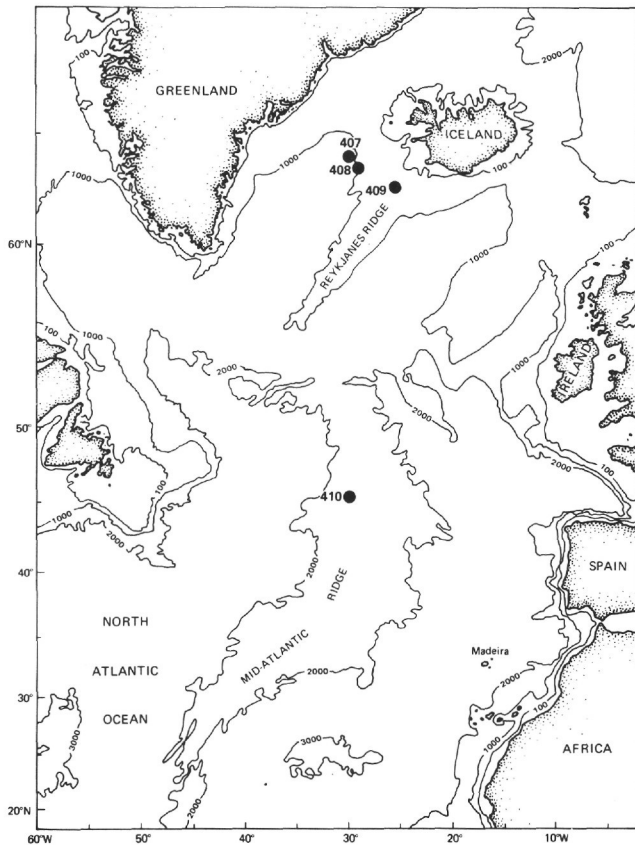


Figure 1. Location of Sites 407 through 410.

TABLE 1  
Abundance of Diatoms in Samples From Site 407

Sample (Interval in cm)	Average Number of Diatoms per Frame	Sample (Interval in cm)	Average Number of Diatoms per Frame	Sample (Interval in cm)	Average Number of Diatoms per Frame
407-1-1, 15	3	407-11-1, 40	8.2	407-24-5, 90	13
407-1-1, 120	0.2	407-11-1, 130	9	407-24-6, 30	27
407-1-2, 20	1.2	407-11-2, 81	11	407-24-6, 132	2.4
407-1-3, 5	2.8	407-11-4, 80	12.8	407-25-1, 10	33.4
407-1-3, 130	2	407-12-1, 90	10.2	407-26-1, 45	12.8
407-1-4, 29	9.2	407-12-2, 50	0.8	407-28-2, 100	26.8
407-1-4, 130	0.2	407-12-3, 66	4.4	407-28-1, 46	38.6
407-1-4, 130	0.2	407-12-3, 66	4.4	407-28-1, 46	38.6
407-2-1, 26	2.6	407-13-1, 70	2.8	407-28-1, 120	31.6
407-2-1, 120	3.4	407-13-2, 90	0.4	407-28-3, 72	16.4
407-2-2, 30	1.8	407-13-3, 70	0	407-28-4, 77	38.6
407-2-2, 130	7.1	407-13-4, 90	0	407-28-5, 59	19.2
407-2-3, 30	6	407-13-5, 73	0	407-29-1, 67	4.6
407-2-3, 120	3	407-13-6, 40	0	407-29-2, 20	16.2
407-2-4, 50	2	407-14-1, 92	21.6	407-29-4, 15	5.4
407-2-5, 30	5	407-14-2, 68	0.4	407-29-5, 15	15.8
407-2-5, 140	1.8	407-14-3, 60	84	407-29-5, 129	15
407-2-6, 100	3.6	407-16-1, 60	0	407-29-6, 54	4.2
407-3-1, 30	4.4	407-16-1, 140	0	407-30-1, 50	5.6
407-3-1, 80	3	407-16-2, 67	0	407-30-1, 127	13.2
407-3-2, 65	1.2	407-16-3, 81	0	407-30-2, 31	7
407-3-2, 65	1.2	407-17-1, 63	0	407-30-2, 115	14.5
407-3-3, 48	0.2	407-17-2, 117	0	407-30-3, 44	21.8
407-3-4, 20	0	407-17-3, 58	0	407-30-3, 134	10
407-4-1, 20	0	407-18-2, 62	0	407-30-4, 30	7.6
407-4-1, 130	0	407-18-2, 123	0	407-30-4, 130	11.8
407-4-2, 110	0.2	407-18-2, 148	1	407-30-5, 30	4.6
407-4-3, 65	5	407-18-3, 18	0.4	407-30-5, 119	11
407-4-3, 130	2	407-18-3, 130	3.4	407-30-6, 50	7.2
407-4-4, 60	0	407-18-4, 29	5.8	407-31-1, 17	7.8
407-5-1, 79	0	407-18-4, 104	2.6	407-31-1, 135	15.4
407-5-2, 27	1.4	407-18-5, 50	1	407-31-2, 21	7.2
407-6-1, 120	0	407-19-1, 50	2.2	407-31-2, 130	3.6
407-6-2, 15	5.6	407-19-2, 90	2.2	407-31-3, 29	5.2
407-6-2, 80	7	407-19-3, 90	2.8	407-31-3, 136	6.8
407-6-3, 57	22	407-19-4, 100	0.6	407-31-4, 84	4.4
407-6-3, 122	16	407-19-5, 54	6.8	407-31-5, 106	5
407-7-1, 5	17.2	407-20-1, 106	16.8		
407-7-1, 115	8.2	407-20-2, 30	26		
407-7-2, 40	15.2	407-21-1, 46	11.4		
407-7-2, 120	24.8	407-22-1, 67	17		
407-8-1, 75	10.6	407-22-2, 83	11.8		
407-8-1, 140	25.2	407-22-3, 62	12.6		
407-8-2, 134	9.6	407-33-1, 138	13.4		
407-8-3, 35	7.6	407-23-2, 90	13.4		
407-9-2, 60	17.4	407-23-3, 60	22.6		
407-10-1, 72	3.6	407-24-1, 14	12.2		
407-10-1, 140	4	407-24-1, 118	5.4		
407-10-2, 93	3	407-24-2, 90	10.4		
407-10-3, 33	5.8	407-24-3, 90	15.8		
407-10-4, 36	5.2	407-24-4, 90	14.6		

this placement is supported by the occurrence of *Annellus californicus* and the first occurrence of *Coscinodiscus lewisianus*. All samples below Core 31 contain only poorly preserved diatom assemblages which do not permit any age determination.

#### SITE 409

Only two samples from Site 409 contain a moderately well preserved diatom flora: Sample 409-2-1, 66 cm (*Rhizosolenia curvirostris*, *R. styliformis*, *Thalassiothrix longissima*, and *Actinocyclus curvatulus*) and Sample

409-7-5, 70 cm (*Coscinodiscus marginatus*, abundant *Chaetoceros* spores and *Stephanopyxis* cf. *turris*). Except for *R. curvirostris*, no age indicator species were observed. Abundances of diatoms in samples from Site 409 are listed below.

Sample (Interval in cm)	Average Number of Diatoms per Frame
409-2-1, 66	2.8
409-2-2, 48	0
409-2-3, 35	0

TABLE 2  
Occurrences of Selected Diatom Species at Site 407

Sample (Interval in cm)	1-1, 15	2-2, 130	3-1, 30	4-3, 65	5-2, 27	6-3, 57	7-2, 40	8-1, 140	9-2, 60	10-3, 33	11-4, 80	12-1, 90	13-1, 70	14-3, 60	19-3, 90	20-2, 30	21-1, 46	22-1, 67	23-2, 90	24-2, 90	25-1, 10	26-1, 45	28-4, 77	29-5, 129	30-5, 119	31-1, 135	31-5, 106		
	F C C R R	A C C F F	R R R A R	C C C C A	A A C F F	F R																							
Abundance	M G G P P	G G G M M	P P P G P	G G G M G	G G P P P	F R																							
<i>Stephanopyxis grunowii</i>																												X	
<i>Stephanopyxis cf. turris</i>						X	X	X										X						X	X			X	X
<i>Actinoptychus undulatus</i>																			X					X	X			X	X
<i>Goniothecium tenue</i>																					X								
<i>Rhizosolenia alata</i>																					X								
<i>Synedra jouseana</i>																					X								
<i>Rhizosolenia styliformis</i>	X		X																		X								
<i>Cymatosira biharensis</i>																						X							
<i>Goniothecium odontella</i>																						X	X						
<i>Thalassionema hirosakiensis</i>																	X	X	X			X	X						
<i>Pseudodimerogramma elliptica</i>																						X	X						
<i>Chaetoceros dicladia</i>																						X	X	X					
<i>Dicladia norwegica</i>																							X						
<i>Ethmodiscus rex</i>																								X					
<i>Melosira sulcata</i>																	X	X	X			X	X	X	X	X			X
<i>Cladogramma dubium</i>																								X	X	X			X
<i>Muelleriella limbata</i>																								X	X	X			X
<i>Pseudopyxilla rossica</i>																								X	X	X			X
<i>Pseudopodosira simplex</i>																								X	X	X			X
<i>Thalassiothrix longissima</i>	X			X	X	X	X	X	X	X				X						X									
<i>Nitzschia maleinterpretaria</i>																				X	X								
<i>Thalassiosira fraga (?)</i>																		X	X	X									
<i>Rhaphidodiscus marylandicus</i>																		X											
<i>Denticula punctata</i>																		X											
<i>Coscinodiscus lewisianus</i>																		X											
<i>Macrora stella</i>																		X											
<i>Thalassionema nitzschioides</i>											X	X			X														X
<i>Rhizosolenia barboi</i>					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X									X
<i>Coscinodiscus marginatus</i>		X		X	X				X	X	X	X	X	X	X	X	X	X	X	X									X
<i>Thalassiosira oestrupii</i>	X					X	X	X	X	X																			X
<i>Thalassiosira eccentrica</i>						X	X	X																					X
<i>Hemidiscus cuneiformis</i>						X	X	X																					X
<i>Actinocyclus ehrenbergii</i>						X	X	X																					X
<i>Rhizosolenia curvirostris</i>	X		X																										X
<i>Pseudoeunotia doliolus</i>					X																								X
<i>Thalassiosira gravida</i>			X	X																									X
<i>Thalassiosira kryophila</i>	X	X	X																										X

- 409-4-2, 66                   0
- 409-5-1, 18                 0
- 409-5-2, 85                 0
- 409-5-3, 18                 0
- 409-6-1, 71                 0
- 409-6-2, 63                 0
- 409-6-3, 83                 1
- 409-7-1, 73                 0
- 409-7-2, 70                 0
- 409-7-4, 60                 0
- 409-7-5, 70                 1

SITE 410

Well-preserved to moderately well preserved Pleistocene diatom floras containing *Pseudoeunotia doliolus*, *Nitzschia marina*, *Thalassiosira lineata*, *T. oestrupii*, *Nitzschia reinholdii*, and *Denticula seminae* (Sample 410-5-3, 95 cm) occur down to Sample 410-6-1, 80 cm. *Nitzschia fossilis*

was first observed in Sample 410-6-3, 80 cm, and places this sample and the following in the Pliocene. Well-preserved to poorly preserved Pliocene diatom floras are present in Samples 410-6-3, 80 cm through 410-16-6, 86 cm; they include *Nitzschia marina*, *N. fossilis*, *N. reinholdii*, *Thalassiosira convexa* (last occurrence in Sample 410-15-1, 80 cm), *Coscinodiscus nodulifer*, *C. africanus*, *Hemidiscus cuneiformis*, and *Rhizosolenia barboi*. Abundances of diatoms in samples from Site 410 are listed below.

Sample (Interval in cm)	Average Number of Diatoms per Frame
410-1-1, 120	0
410-1-2, 90	0.6
410-1-3, 91	24.4

410-1-4, 35	0.8
410-1-5, 86	0
410-2-1, 85	11.8
410-2-2, 60	0.2
410-2-3, 92	9
410-3-1, 91	3.8
410-3-2, 90	1.6
410-3-3, 90	2
410-4-1, 70	0.2
410-4-2, 70	0
410-4-3, 70	0.2
410-4-4, 80	16.0
410-5-1, 80	2.2
410-5-2, 70	5.8
410-5-3, 95	21.6
410-5-4, 90	8.8
410-5-5, 80	0
410-5-6, 70	0.4
410-6-1, 80	1.8
410-6-2, 80	0
410-6-3, 80	1.6
410-7-1, 80	0.6
410-7-2, 37	0
410-8-1, 70	0.8
410-8-2, 80	1.8
410-8-3, 80	1.8
410-8-4, 88	24.2
410-8-5, 80	2.0
410-8-6, 80	25.8
410-10-1, 80	0.4
410-10-2, 120	0
410-10-3, 80	0.2
410-10-4, 90	0
410-10-5, 80	0.8
410-10-6, 130	1.6
410-11-1, 80	3.6
410-11-2, 100	0
410-11-3, 80	2.8
410-11-4, 70	1.4
410-11-5, 80	0.6
410-11-6, 80	1.2
410-13-1, 79	0
410-13-2, 30	0.2
410-14-1, 80	2.0
410-14-2, 90	2.8
410-14-3, 90	0
410-14-4, 110	8.4
410-14-5, 80	14.2
410-14-6, 90	29.6
410-15-1, 80	2.8
410-15-2, 100	0.2
410-15-3, 100	0.6
410-15-4, 80	0
410-15-5, 80	0.6
410-15-6, 70	0
410-16-1, 84	0.8
410-16-2, 90	18.6
410-16-3, 80	6.4
410-16-4, 80	0
410-16-5, 80	3
410-16-6, 86	2.4

## ACKNOWLEDGMENTS

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## REFERENCES

Burckle, L. H. 1972. Late Cenozoic planktonic diatom zones from the eastern equatorial Pacific, *Nova Hedwigia, Beiht.*, v. 39, p. 217-250.

TABLE 3  
Abundances of Diatoms in Samples From Site 408

Sample (Interval in cm)	Average Number of Diatoms per Frame	Sample (Interval in cm)	Average Number of Diatoms per Frame
408-1-1, 66	5.6	408-28-3, 81	58.4
408-1-2, 111	0	408-29-2, 66	47.2
408-1-3, 85	0	408-30-1, 34	49.8
408-1-4, 78	0.2	408-30-3, 41	29.2
408-1-5, 55	0	408-30-4, 79	24
408-1-6, 57	11	408-31-2, 80	0.4
408-2-1, 67	0	408-31-1, 92	0.4
408-2-2, 80	0	408-31-3, 96	0
408-2-3, 60	0	408-12-1, 106	46.4
408-2-4, 123	1.6	408-12-2, 75	27.8
408-2-5, 95	0	408-13-1, 26	3
408-3-1, 75	0	408-13-1, 127	9.2
408-3-2, 133	3.2	408-13-2, 64	4.4
408-3-3, 82	8.4	408-13-3, 70	18.6
408-3-4, 47	3.4	408-15-1, 80	3.4
408-3-5, 23	1.6	408-15-2, 107	8.8
408-4-1, 103	6.6	408-15-3, 87	13.4
408-4-2, 35	0	408-15-4, 80	5
408-4-3, 70	4.6	408-15-5, 49	23.4
408-4-4, 110	4.4	408-16-1, 136	54.8
408-4-5, 43	8.4	408-16-2, 70	0
408-5-1, 59	15.6	408-15-3, 35	0.2
408-5-2, 136	12	408-17-1, 66	0.4
408-5-3, 20	39.6	408-17-2, 70	0.4
408-5-3, 125	52.2	408-17-3, 80	1.6
408-5-4, 37	51.2	408-17-4, 80	1
408-5-4, 120	29.8	408-17-5, 46	0
408-6-1, 83	31.2	408-18-1, 127	0
408-6-2, 84	13.8	408-18-2, 90	0
408-6-3, 60	2.8	408-18-3, 109	0
408-7-1, 60	20.8	408-19-1, 117	0
408-8-1, 75	32.8	408-19-2, 70	0
408-8-2, 62	37.4	408-19-3, 80	4.4
408-9-1, 61	22.2	408-19-4, 70	0
408-9-2, 67	31	408-19-5, 70	0
408-10-1, 71	39.6	408-19-6, 69	10.8
408-10-2, 80	11.4	408-20-1, 70	6.4
408-10-3, 81	14.8	408-20-2, 79	0.8
408-10-4, 80	4.2	408-21-2, 80	34
408-10-5, 34	26.2	408-21-3, 80	22.8
408-11-1, 113	0.8	408-22-1, 75	34.8
408-11-1, 137	33.2	408-22-2, 67	17.4
408-11-2, 41	5	408-22-3, 74	16.4
408-11-2, 110	33.2	408-23-2, 80	32.8
408-11-3, 30	30	408-24-1, 66	36.2
408-11-3, 119	6.6	408-24-2, 116	22
408-11-4, 125	18.6	408-24-5, 87	23
408-11-5, 86	51.6	408-25-2, 86	44.2
408-27-1, 80	24.4	408-25-3, 109	27.6
408-27-2, 80	32.4	408-25-5, 85	29.2
408-27-3, 70	20	408-25-6, 90	31.8
408-27-4, 71	33	408-26-1, 64	18
408-27-5, 133	21.6	408-26-2, 49	13.6
408-27-6, 80	20.2	408-26-3, 88	26
408-28-1, 125	26.2	408-26-4, 111	36.6
408-28-2, 110	65.6	408-26-5, 80	23.8

Koizumi, J. 1977. Diatom biostratigraphy in the North Pacific Region, *Proc. First Intern. Congress on Pacific Neogene Stratigraphy*, Tokyo, 1976, p. 235-253.

Schrader, H.-J., 1974. Proposal for a standardized method of cleaning diatom bearing deep-sea and land-exposed marine sediments, *Nova Hedwigia, Beiht.*, v. 45, p. 403-409.

Schrader, H.-J. and Fenner, J. 1976. Norwegian Sea Cenozoic diatom biostratigraphy and taxonomy. In Talwani, M., Udintsev, G., et al., *Initial Reports of the Deep Sea Drilling Project*, v. 38: Washington (U.S. Government Printing Office), p. 921-1099.

TABLE 4  
Occurrences of Selected Diatom Species at Site 408

Sample (Interval in cm)	1-1, 66	3-3, 82	4-5, 43	6-1, 83	7-1, 60	8-1, 75	9-1, 61	10-1, 71	11-2, 110	12-1, 106	13-3, 70	15-5, 49	16-1, 136	19-6, 69	20-1, 70	21-3, 80	22-3, 74	24-5, 87	25-6, 90	26-4, 111	27-6, 80	28-3, 81	29-2, 66	30-4, 79
Abundance	F	C	F	C	F	F	F	A	A	A	F	F	A	F	A	A	A	A	A	A	A	A	A	A
Preservation	M	M	M	G	M	M	M	M	M	M	M	M	G	M	G	G	G	G	G	G	G	G	G	G
<i>Thalassionema nitzschioides</i>			X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
<i>Thalassiothrix longissima</i>	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
<i>Actinocyclus ingens</i>														X	X	X								
<i>Coscinodiscus lewisianus</i>																							X	X
<i>Annellus californicus</i>																								X
<i>Denticula nicobarica</i>																						X	X	
<i>Denticula punctata</i>																				X	X	X		
<i>Denticula dimorpha</i>																				X				
<i>Denticula hustedtii</i>														X	X	X	X					X	X	X
<i>Denticula lauta</i>																				X	X			
<i>Cladogramma dubium</i>																					X	X	X	X
<i>Macrora stella</i>																					X	X	X	
<i>Coscinodiscus "plicatus" Group</i>																X	X			X	X	X		
<i>Goniothecium tenue</i>																				X	X		X	X
<i>Coscinodiscus marginatus</i>		X	X	X	X	X	X	X	X	X	X	X	X				X				X	X	X	
<i>Mediaria splendida</i>														X	X	X				X	X	X	X	
<i>Cussia lancettula</i>																				X			X	
<i>Rhizosolenia praebarboi</i>																X	X			X	X			
<i>Rhizosolenia barboi</i>		X	X		X	X	X		X	X	X	X	X							X	X			
<i>Rhizosolenia curvirostris</i>																								
<i>Hemidiscus cuneiformis</i>																								
<i>Nitzschia fossilis</i>		X							X	X			X											
<i>Nitzschia reinholdii</i>						X	X		X	X			X											
<i>Nitzschia spec.</i>								X	X				X											
<i>Thalassiosira oestrupii</i>			X			X	X	X	X				X											
<i>Cosmidiscus insignis</i>								X	X	X			X											
<i>Mediaria splendida var. tenera</i>																								
<i>Thalassiosira grvida</i>	X																							