

LATE CRETACEOUS FLYSCH-TYPE AGGLUTINATED FORAMINIFERA FROM THE NORTHERN ITALIAN APENNINES

by

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With 5 figures and 1 table

ZUSAMMENFASSUNG

Untersucht wurde eine agglutinierte Tiefwasser-Foraminiferenfauna aus dem Solignano und Monte Cassio Flysch des nördlichen Apennin (Italien). Nach kalkigem Nannoplankton ist der gesamte Solignano Flysch Untermaastricht, während der basale Monte Cassio Flysch den Zeitraum Obercampan bis Untermaastricht umfaßt. Beide Formationen wurden nahe oder unter der CCD (Auflösungstiefe für Kalziumkarbonat) abgelagert.

Die mikropaläontologische Auswertung wies im Solignano Flysch 63 und im Monte Cassio Flysch 36 Taxa nach, die v.a. zu den Astrorhizacea, Hyperamminacea, Ammodiscacea, Hormosinacea und Lituolacea gehören. Eine inverse Korrelation zwischen Gesamtfauenenhäufigkeit und CaCO₃-Gehalt der Proben wurde festgestellt. Die höchsten Häufigkeiten und Diversitäten fallen mit den geringsten Karbonatgehalten zusammen. Dies weist darauf hin, daß die Untersättigung von Karbonat die Diversifizierung und Häufigkeit agglutiniertes Tiefwasserforaminiferen nicht nur erlaubt, sondern begünstigt. Diese Beobachtung stellt eine Arbeitshypothese dar, die an vergleichbaren Tiefwasserabfolgen getestet werden soll.

ABSTRACT

Deep-water agglutinated foraminifera were studied from the Solignano and Monte Cassio Flysch of the northern Apennines, Italy.

Calcareous nannofossil data indicate that the Solignano Flysch is entirely Early Maastrichtian in age, whereas the base of the Monte Cassio Flysch spans the Late Campanian-Early Maastrichtian interval; both formations are widely considered to have been deposited near or below the carbonate compensation depth.

Micropalontological analyses resulted in the identification of sixty-three taxa from the Solignano Flysch and thirty-six taxa from the Monte Cassio Flysch, mostly belonging to the superfamilies Astrorhizacea, Hyperamminacea, Ammodiscacea, Hormosinacea and Lituolacea.

An inverse correlation was found between the total faunal abundance and the calcium carbonate content of the samples; the highest abundances and generic and specific diversities closely match the lowest carbonate values. This suggests that undersaturation with respect to calcium carbonate not only allowed, but also favored the diversification and numerical growth of agglutinated deep-water foraminifera assemblages. This observation is a tentative working hypothesis to be tested through further analyses of coeval deep-water sequences.

INTRODUCTION

During the Late Cretaceous, intrabasinal carbonate turbidites were deposited in the Italian northern Apennines area during a slow collisional event between Europe and Africa (Mutti *et al.* 1984). These turbidites are widely interpreted as a trench-wedge fill (Sagri 1979b) which was deposited near or below the carbonate compensation depth (Scholle 1971, Sagri 1979a, Sagri and Marri 1980, Abbate and Sagri 1982).

This paper deals with the agglutinated foraminifera of two of these turbiditic sequences, namely the Solignano Flysch and the Monte Cassio Flysch of the Parma province, northern Italy (fig. 1). The type-section of the Monte Cassio Flysch, which outcrops in the Baganza Valley (Papani and Zanzucchi 1970) is composed of some 1300 m of regular and monotonous turbiditic sequences of calcarenites or calcareous sandstones, marls and hemipelagic shales (Zanzucchi 1961, 1967).

The Solignano Flysch, first described by Zanzucchi (1961) is composed of about 500 m of turbiditic deposits, in which terrigenous content markedly increases upwards (Rio and Villa 1983); detailed lithological descriptions are reported in Abbate and Sagri (1970). Further information on both these formations and the regional geology of the area can be found in Zanzucchi (1980).

Recently, the calcareous nannofossil assemblages of the two sequences were studied by Rio and Villa (1983) and by Rio *et al.* (1983). The authors assigned the Solignano Flysch to the early Maastrichtian *Tetralithus trifidus* and *Arkhangelskiella cymbiformis* Zones and the base of the Monte Cassio

Flysch to the Late Campanian-Early Maastrichtian (*Tetralithus trifidus* Zone). No systematic study was until now carried out on the agglutinated foraminifera of these formations; the only available quotations from any northern Apennines Cretaceous turbiditic sequence and related basal complex can be found in Montanaro Gallitelli (1948, 1953).

MATERIALS AND METHODS

Forty-seven samples in the Solignano Flysch (closely corresponding to the sampling of Rio and Villa, 1983) and twenty samples in the Monte Cassio Flysch were studied. The sampling was limited to the layers considered to be of hemipelagic origin (following field criteria of Hesse 1975), in order to minimize the possibility of re-sedimentation and/or reworking, the layers immediately underlying the thickest turbiditic beds were discarded.

An average weight of one thousand grams of sediment was processed for each sample; steps included mechanical disaggregation, oven-drying, soaking and boiling in highly concentrated hydrogen peroxide and wet sieving through a 63 micron sieve. All the agglutinated foraminifera in ten grams of dried residue were then sorted, counted and classified.

The micropaleontological content of the samples (almost entirely made up of agglutinated foraminifera tests; see later) ranges from scarce to abundant; five classes of frequency were established in order to express the total faunal abundance. Classes 1, 2, 3 indicate the number of individuals in ten grams of dried residue ranging respectively from 1 to 100, from 101 to 500, and from 501 to 1000.

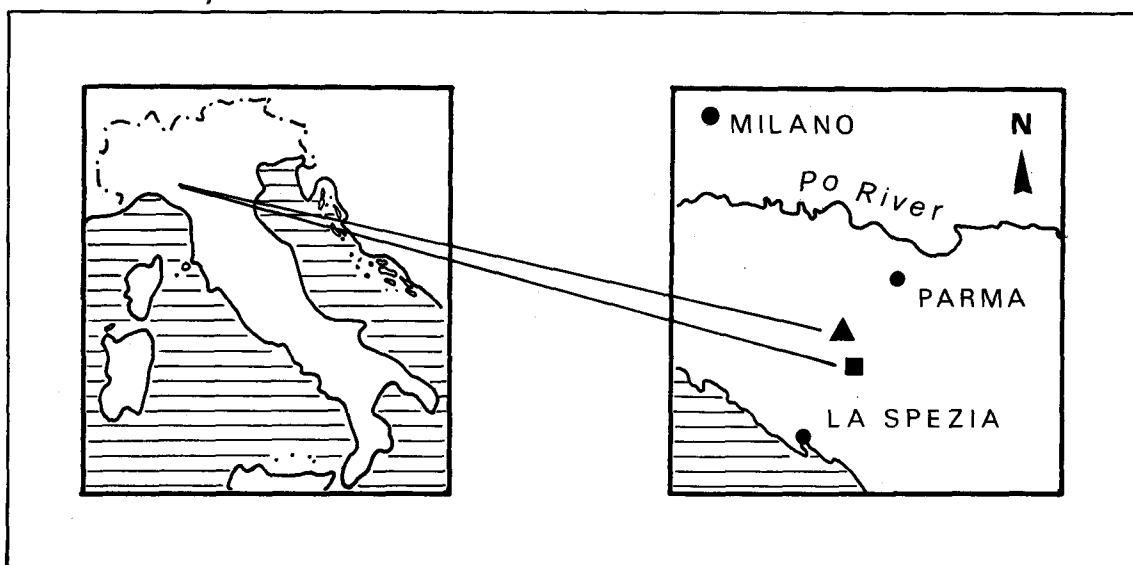


Fig. 1.
Location map of the studied sequences.
▲ = Solignano Flysch; ■ = Monte Cassio Flysch.

Class 4 indicates more than 1001 (sometimes up to 6000) individuals, and finally class 0 indicates barren samples (figs. 2, 3). The occurrence of each species in a sample was quantified and recorded as a numerical percentage.

FAUNAL COMPOSITION

Ten of the forty-seven samples of Solignano Flysch and four of the twenty samples of Monte Cassio Flysch were barren of foraminifera. The remaining hemipelagic layers of both formations contain almost exclusively agglutinated foraminifera in a good to excellent state of preservation; calcareous benthic foraminifera and planktonic foraminifera are absent and only sporadically rare pyritized radiolarians and fish teeth and/or debris were found.

The agglutinated foraminifera are mainly referable to primitive types, i.e., single (straight or branched) tubes or chambers, single coiled tubes and uniserial multichambered tests. However more "sophisticated" species are also present in subordinate numbers. All the occurring taxa in both sections are listed alphabetically in table 1 and their distribution is briefly discussed.

The Monte Cassio Flysch and Solignano Flysch faunas are composed respectively of twenty-nine and fifty-two recognized species, belonging to fifteen and twenty-seven genera, plus a number of taxa determined only at a generic level (figs. 2, 3). The difference in generic and specific diversities between the two sections can be explained by the more widely spaced sampling of Monte Cassio Flysch, which could have prevented the finding of some less common or rare taxa.

The most commonly represented species in both cases are *Bathysiphon brosgiei*, *B. vitta*, *Rhabdammina cylindrica*, *R. latissima*, *R. robusta* and *R. indivisa*; *Hippocrepina depressa* and *Bathysiphon discretus* are fairly abundant in Monte Cassio and Solignano Flysch respectively, whereas *Ammodiscus cretaceus*, *Glomospira irregularis*, *G. gordialis*, *Hyperamminta elongata*, *Kalamopsis grzybowskii* and *Saccammina placenta* are sometimes common.

Such a dominant assemblage bears a good resemblance to the so-called *Rhabdammina* fauna of Brouwer (1965), as well as to type B of flysch-type agglutinated assemblages of Gradstein and Berggren (1981). This assemblage is consistently present in all samples, regardless of their total

LATE CAMPANIAN - EARLY MAASTRICHTIAN	A B E		SPECIES																												TOTAL ABUNDANCE													
	MANOZZE (after Rio et al., 1983)	SAMPLES	BATHYSIPHON BROSGEI	BATHYSIPHON VITTA	LOENOROPHYA EXCELSA	GLOMOSPIRA GORDIALIS	HIPPOCREPINA DEPRESSA	RHABDAMMINA CYLINDRICA	RHABDAMMINA LATISSIMA	RHABDAMMINA ROBUSTA	RHIZAMMINA ALGAEFORMIS	RHIZAMMINA INDIVISA	TROCHAMMINOIDES CONGLOBATUS	BATHYSIPHON CALIFORNICUS	BATHYSIPHON DISCRETUS	RZEHALINA SP.	SACCAMMINA SPP.	SACCAMMINA PLACENTA	TROCHAMMINA SPP.	TROCHAMMINOIDES CORONATUS	TROCHAMMINOIDES PROTEUS	AMMODISCUS CRETACEUS	LITUOTUBA IRREGULARIS	GLOMOSPIRA IRREGULARIS	TROCHAMMINOIDES SPP.	TROCHAMMINOIDES IRREGULARIS	HYPERAMMINA ELONGATA	REOPHAX PILULIFER	GLOMOSPIRA SPP.	UVIGERAMMINA JANKOI		HORMOSINA OVULUM	LITUOTUBA SP.	RHABDAMMINA DISCRETA	KALAMOPSIS GRZYBOWSKII	RHABDAMMINA LINEARIS	LITUOTUBA LIUTIFORMIS	REOPHAX MINUTUS	HORMOSINA SP.	UNDETERMINED				
Ca 20	2.2	232	0.6	0.3	0.6	28.1	9.3	18.1		4.1	0.3									0.3	0.6		4.8			0.3														0.6	0.6	4		
Ca 19																																												0
Ca 18	33.1				9.5	34.3		15.1	0.5		0.5									0.5																							1	
Ca 17																																											0	
Ca 16	8.0				4.9	22.8	21.0	29.2			0.9		0.9					0.6		0.6	0.8	0.9	0.9			1.8							1.5	0.3			2.5	0.6			1.8	3		
Ca 15	13.5				10.0	19.7		48.3	0.3												3.2					1.2						0.3				2.3					1.2	3		
Ca 14																																										0		
Ca 13	9.5				13.7	36.2	28.1	5.9		0.6								0.3			1.8	0.6	0.6			1.0						0.3				1.0				0.6	4			
Ca 12	2.2					26.6	15.5				4.4												2.2													49.1					3			
Ca 11		0.6				25.4	73.1		0.9																																4			
Ca 10	3.7	2.9	0.7			13.2	12.5	65.6																																0.7	2			
Ca 9	8.6	4.1	0.8			1.2	35.7	25.3	25.3																												0.4	0.4			3			
Ca 8	7.4	0.5	0.9	0.5	24.6	14.7	12.9	0.9		23.5			7.8				0.5	0.9		1.3																0.9	0.5			2.3	3			
Ca 7	18.4	59.4			3.9													1.3								1.3	1.3														13.1	3		
Ca 6																																										0		
Ca 5	10.3	65.4	0.3		7.7	0.5		8.3	1.1	3.7										0.3					1.1	0.3	0.3														0.6	4		
Ca 4	6.9	13.3	4.4			33.8	25.9	4.1	10.4				0.6									0.3																			0.3	2		
Ca 3	35.7	19.8	0.9			8.4	17.8	8.1	7.8				0.6							0.3	0.3																				0.3	2		
Ca 2	12.5	31.5			1.2	8.4	8.4	7.6	0.8	7.2	0.4	4.8	6.4	0.4	0.5	2.4	0.8	2.3	0.4																						4.0	4		
Ca 1	10.7	24.6	0.8	0.6	3.1	13.2	21.2	9.4	3.4	12.6	0.3																														0.6	4		

Fig. 2. Agglutinated foraminifera distribution in Monte Cassio Flysch. Species abundances are expressed as numerical percentages; total abundance (column on the right) indicates the number of individuals per ten grams of dried residue. 0 = barren; 1 = 1-100; 2 = 101-500; 3 = 501-1000; 4 = >1000.

A G E		Namozone (after Rio & Vitto, 1983)																																			
S A M P L E S		S P E C I E S																																			
		TROCHAMMINOIDES CORONATUS	AMMODISCUS CRETACEUS	GLIOMSPIRA GORDIALIS	SACCAMMINA COMPLANATA	SPIROPECTAMMINA CHICANA	TROCHAMMINOIDES IRREGULARIS	HORMOSINA EXCELSA	HORMOSINA CRASSA	PSEUDOBOLIVINA MUNDA	AMMODISCUS CF. TENUIS	BATHYSIPHON CALIFORNICUS	GLIOMSPIRA spp.	REOPHAX SPLENDIDUS	TROCHAMMINOIDES spp.	HORMOSINA sp.	RECURVOIDES CONTORTUS	REOPHAX HORRIDUS	HAPLOPHRAGMOIDES NORLIONI	PSEUDOBOLIVINA NORMALIS	AMMODISCUS PENNYI	HORMOSINA GIGANTEA	HORMOSINA OVULOIDES	HYPERAMMINA ELONGATA	SACCAMMINA SPHAERICA	SOROSPHAERA sp.	RHABDAMMINA DISCRETA	RHABDAMMINA LINEARIS	HAPLOPHRAGMOIDES DECUSSATUS	HORMOSINA OVULUM	PLECTORECURVOIDES sp.	ARENOLIMINA sp.	UNDETERMINED	TOTAL ABUNDANCE			
S 47	0.3						0.7																										0.9	2.1	3		
S 46													0.7																			0.3	1.1	1.4	4		
S 45		B A R R E E N																																			0
S 44																																				0	
S 43	0.5											0.8	0.4																						4.0	4	
S 42																																				1	
S 41							1.3													1.3												3.9			4		
S 40		B A R R E E N																																			0
S 39																																				0	
S 38							0.4																												1.5	2	
S 37																																				0	
S 36		0.6					1.3													0.3		0.8												1.0	3		
S 35																																1000			0.0	1	
S 34																																				0	
S 33																								0.5			12.1	0.5							5.2	2	
S 32																																				4	
S 31																																				3	
S 30																																				0	
S 29														0.9	0.4																				5.3	2	
S 28																																			487	1	
S 27	0.4	0.8				0.4							0.4						0.4															1.3	3		
S 26	1.2	2.8				0.6							0.3					0.9																1.6	4		
S 25	1.1					2.2						1.1	0.7	1.2	0.6																		0.4	4			
S 24	0.4	1.5										0.5	2.5	0.5																			5.4	4			
S 23																																				0	
S 22																																				0	
S 21																																				0	
S 20																																				0	
S 19																																				0	
S 18																																				0	
S 17													5.1																						4.9	3	
S 16	0.9																																		10.0	3	
S 15							1.8	3.7																											0.0	3	
S 14																																			5.9	2	
S 13																																			24.9	1	
S 12	3.5		1.1	2.1	1.7	0.3																												3.9	4		
S 11																																			25.8	1	
S 10																																				0	
S 9	0.4	0.6	0.4	0.5	0.3	0.9																													0.9	3	
S 8	0.6																																		0.3	3	
S 7																																				0	
S 6																																				2.4	4
S 5																																				0	
S 4																																			29.4	2	
S 3																																				0	
S 2																																				0	
S 1																																				0	

Fig. 3. Agglutinated foraminifera distribution in Solignano Flysch. Species abundances are expressed as numerical percentages; total abundance (column on the right) indicates the number of individuals per ten grams of dried residue. 0 = barren; 1 = 1-100; 2 = 101-500; 3 = 501-1000; 4 = >1000.

A G E	MANNONIC (after Rio & Vitto, 1983)																																			
	S A M P L E S																																			
S 47	S P E C I E S																																			
	BATHYSIPHON VARANS	BATHYSIPHON VITTA	DENDROSPHRA EXCELSA	KALAMOPSIS GRZYBOWSKI	LITUOTUBA sp.	REOPHAX sp.	RHABDAMMINA ROBUSTA	TEXTULARIA sp.	TROCHAMMINOIDES PROTEUS	BATHYSIPHON BROSGEII	BATHYSIPHON DISCRETUS	BIBERININA cf. JURASSICA	GLOMOSPIRA VARIABILIS	GLOMOSPIRELLA GAULTINA	HIPPOCREPINA DEPRESSA	LITUOTUBA LIUTIFORMIS	REOPHAX DUPLEX	REOPHAX ELONGATUS	REOPHAX MINUTUS	REOPHAX MULTICULARIS	RHABDAMMINA CylINDRICA	RHABDAMMINA LATISSIMA	RHIZAMMINA INDIVISA	SACCAMMINA PLACENTA	TROCHAMMINOIDES CONGLOBATUS	TROCHAMMINA spp.	AMMODISCUS PERUVIANUS	GLOMOSPIRA IRREGULARIS	HYPERAMMINA GAULTINA	LAGENAMMINA sp.	LITUOTUBA IRREGULARIS	REOPHAX PILULIFER				
S 47	10.3	1.4	0.3	1.4	2.1				2.8					0.3						16.1	45.6	8.2	1.4													
S 46	31.7	0.7		0.3	0.2	0.8														13.8	42.3	6.3	0.2	0.4												
S 45	B A R R E N																																			
S 44																																				
S 43	9.7	0.8			0.4	5.7			2.0	2.1		0.3	0.4	0.8						42.6	24.3	6.1	0.8	0.4					0.7							
S 42														3.9						28.2	4.9	16.0														
S 41	5.1				2.5				2.7	8.8				2.6						29.4	16.7	8.9	5.1	1.3									2.6			
S 40	B A R R E N																																			
S 39																																				
S 38	54.8								4.9	2.9				1.9						17.3	14.6	3.7														
S 37	B A R R E N																																			
S 36	0.3	7.9	0.6			1.0	1.3		1.0											13.4	58.1	11.1	0.7	0.5					0.3							
S 35	B A R R E N																																			
S 34	B A R R E N																																			
S 33	5.2	2.6			3.7	1.6		1.6												21.5	28.3	16.2		0.5											0.5	
S 32	42.2	0.4		0.4										7.7						11.3	22.6	3.6	1.8					0.4								
S 31	7.5	0.7			0.3		0.3	0.3												18.8	54.2	13.4	1.4													
S 30	B A R R E N																																			
S 29	33.4			0.9	0.4		3.5	1.3					0.9	1.3						22.6	8.4	2.2	3.1			1.3		4.0						0.4		
S 28	12.2						4.9	4.9					4.9							4.9	12.2	4.9	2.4													
S 27	44.2						2.1	1.3					0.8	0.4						12.3	29.7	5.1		0.4												
S 26	12.4	1.6	0.3		6.3		0.9	3.1				0.3		0.3	0.9					9.6	38.1	8.2	5.7	0.8	1.0			0.3		2.8						
S 25	5.9	1.6			1.4		1.1	1.1	4.1						1.1					11.2	57.1	4.8	1.8	1.1												
S 24	8.1	2.9		1.0	1.1		1.4	0.9	4.6						0.5	0.4				36.8	27.3		2.5	1.5											0.6	
S 23	B A R R E N																																			
S 22	B A R R E N																																			
S 21	B A R R E N																																			
S 20	B A R R E N																																			
S 19	B A R R E N																																			
S 18	B A R R E N																																			
S 17	40.1	4.9		4.7	5.3				14.6												15.4	5.0														
S 16	3.1																			33.9	8.0	35.9	6.1	2.1												
S 15	13.0			1.8	3.7	1.3			11.1											9.2	18.8		7.4													
S 14	17.6																			23.5	11.7	35.4	5.9													
S 13							8.3	16.6													33.6	16.6														
S 12	4.9	1.1			7.1		0.7					0.7	1.1							35.9	3.2	18.7	9.2		1.6		1.8									
S 11	9.6																			58.2		6.4														
S 10	B A R R E N																																			
S 9	30.4	2.6			3.0		16.8	3.4					3.4							10.8	10.3	11.6	0.9	0.4			0.9	1.3								
S 8	8.8	0.6			15.8		0.6	5.1	2.0			1.0	2.4							9.5	13.2	16.6	7.5	0.6	2.7	1.0	1.7	5.4	0.3	3.0	1.3					
S 7	B A R R E N																																			
S 6	19.6	0.5			0.9	1.4	10.5	1.4	0.4	0.6	0.5	1.4	0.5	0.7	0.3	0.4	0.6	2.39	19.6	10.5	2.9	0.4	0.6													
S 5	B A R R E N																																			
S 4	4.1	4.1	16.6	4.1	3.9	4.3	25.3	4.0	4.2																											
S 3	B A R R E N																																			
S 2	B A R R E N																																			
S 1	B A R R E N																																			

Fig. 3 (continued).

abundance (as previously defined), but the less common, more "sophisticated" species occur only in samples characterized by highest total abundances.

A single peak of *Rhabdammina discreta* was recorded in both sections, with a percentage of 12.1% of the total assemblage in Solignano Flysch (sample S 33) and of 49.1% in Monte Cassio Flysch (sample Ca 12). Since *R. discreta* is a long-ranging taxon, this single massive occurrence has obviously no biostratigraphic meaning; it could rather reflect some variations in the paleoenvironmental parameters, slight enough as not to modify the bulk assemblage, but effective enough as to allow the species, elsewhere absent, to bloom.

Finally it is noteworthy that in both sections a few samples are characterized by a high (up to 48.7%) percentage of undetermined forms, because of strong pyritization which affects all the fauna and in most instances prevents a generic or specific assignment. This abundance of pyrite, either as test replacement or as small discrete phenocrysts, could testify to some local episodes of reducing pore water conditions.

AGGLUTINATED FORAMINIFERA VS. CaCO₃ CONTENT

Quantitative CaCO₃ determinations were carried out on the 67 samples collected from the hemipelagic

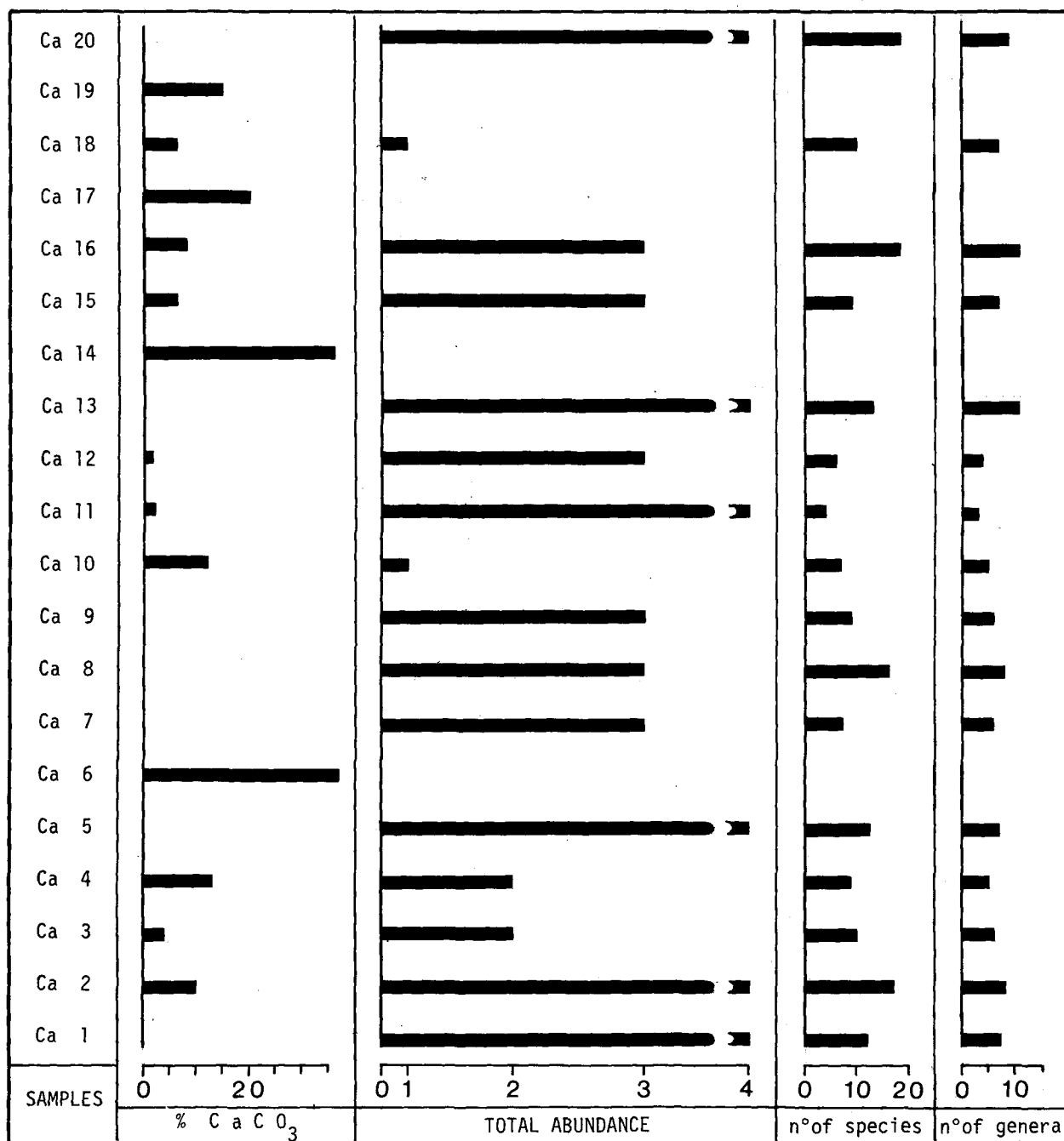


Fig. 4. Compared histograms of calcium carbonate percentage, total abundance, number of species and number of genera in Monte Cassio Flysch samples.

layers of the two studied sections, in order to investigate if some relationship exists between the calcium carbonate content of the sediment and the agglutinated foraminifera assemblages.

The obtained values were tabulated as histograms, where the calcium carbonate content of each sample is compared with the total faunal abundance (as previously defined), the number of genera and the number of species (fig. 4-5).

The comparative evaluation of the histogram patterns shows that in both the Solignano and Monte Cassio Formations, a striking inverse correlation exists between calcium carbonate

percentages and faunal parameters: lowest CaCO_3 values correspond to highest abundances of specimens and to highest generic and specific diversities. On the other hand, if calcium carbonate percentages exceed a threshold value of 15%, the samples are completely barren. The only exception is sample S 35, (fig. 5), the faunal content of which is represented only by two specimens of *Haplophragmoides decussatus*, which are probably reworked.

CONCLUSIONS

It is widely known that in deep-sea abyssal plain or trench sediments deposited at (paleo)depths near or

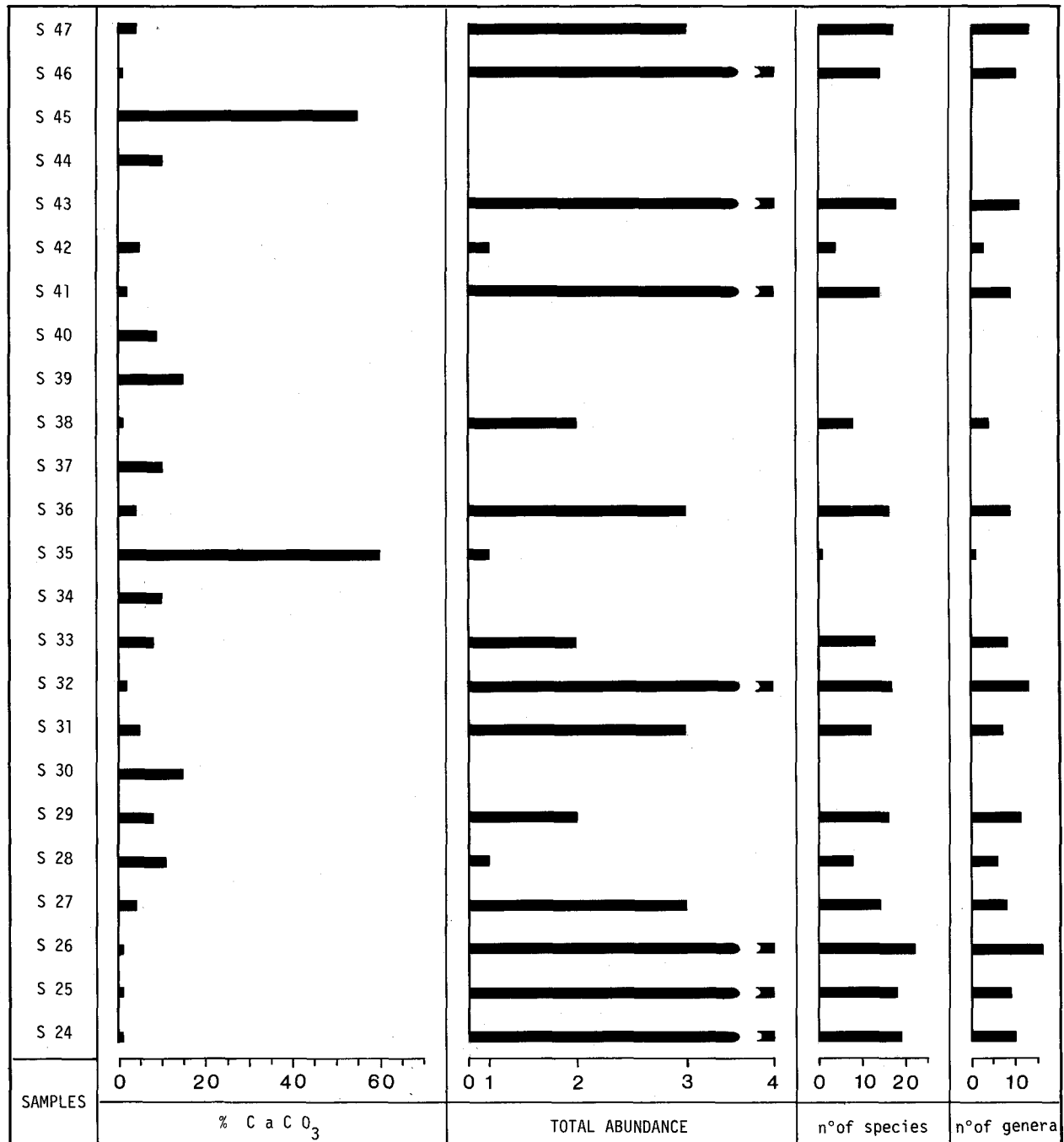


Fig. 5. Compared histograms of calcium carbonate percentage, total abundance, number of species and number of genera in Solignano Flysch samples.

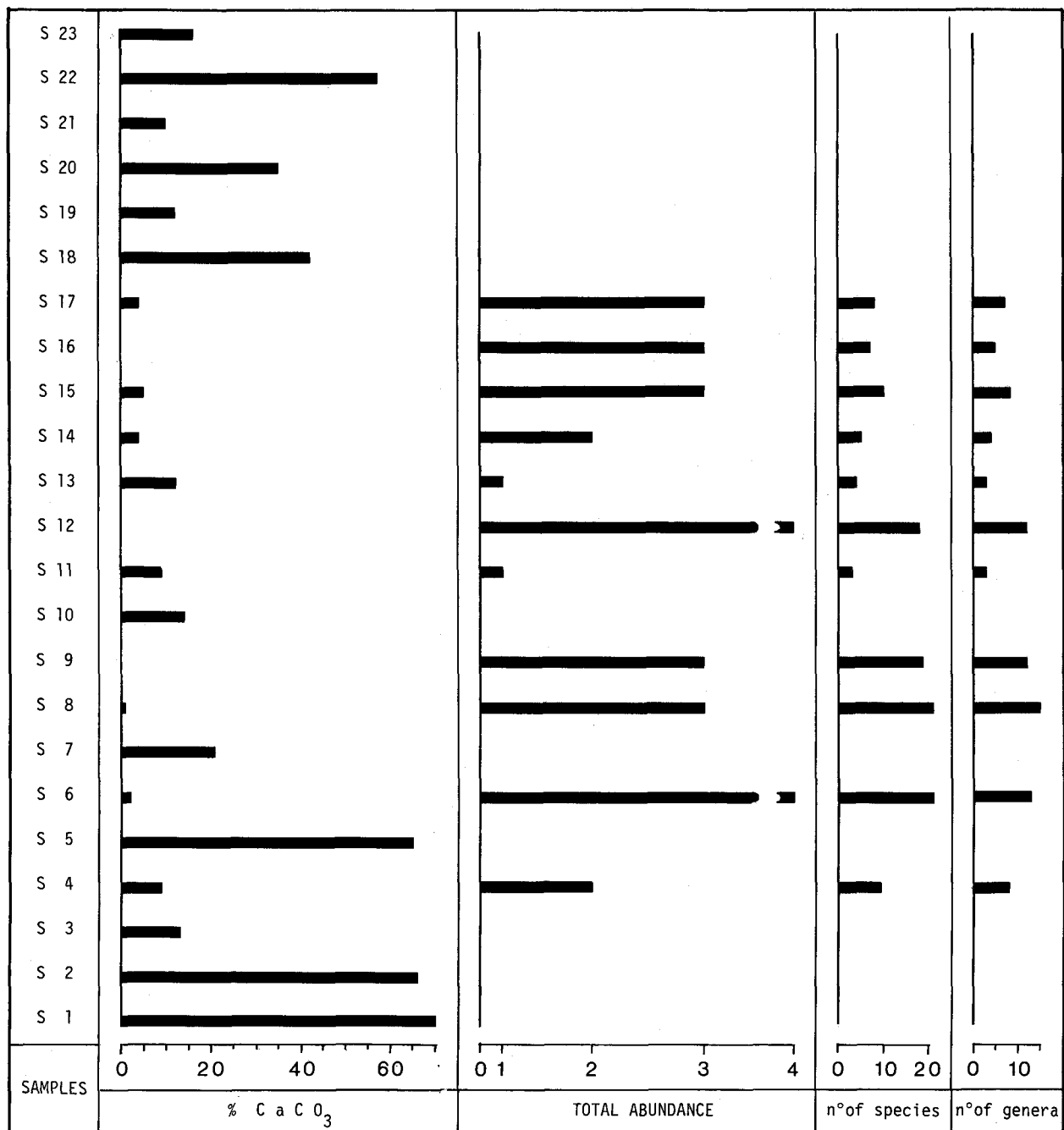


Fig. 5 (continued).

below the CCD only agglutinated foraminifera among benthic forms can be found; radiolarians are sometimes present among the planktonic forms, together with some calcareous nannofossils whose sinking and deposition via fecal pellets protected them from dissolution.

Therefore it is not surprising that these hemipelagic layers from flysch formations which are considered to have been deposited near or below the CCD, contain a significant amount of dissolution-resistant agglutinated tests. In fact, the relative abundance of agglutinated foraminifera in such deep-water facies is easily accounted for by a selective enrichment of

an otherwise diluted fauna, because of the absence of calcareous benthic forms and of the dissolution of planktonic tests during their sinking in the water column.

Therefore the studied hemipelagic layers, being the sedimentary expression of a fairly stable depositional environment characterized by scarce or absent terrigenous supply and by CaCO₃-unsaturated or near-undersaturated bottom water conditions, were expected to contain a constant amount of agglutinated foraminifera. On the contrary, a striking inverse relationship was shown between the calcium carbonate and agglutinated

Table 1.
Alphabetical list of the taxa occurring in Solignano (SF) and Monte Cassio (MC) Formations.

TAXA	SF	MCF	TAXA	SF	MCF
<i>Ammodiscus cretaceus</i>	*	*	<i>Pseudobolivina munda</i>	*	
<i>Ammodiscus pennyi</i>	*		<i>Pseudobolivina normalis</i>	*	
<i>Ammodiscus peruvianus</i>	*		<i>Recurvoides contortus</i>	*	
<i>Ammodiscus cf. tenuis</i>	*		<i>Reophax duplex</i>	*	
<i>Arenobulimina sp.</i>	*		<i>Reophax elongatus</i>	*	
<i>Bathysiphon brosegi</i>	*	*	<i>Reophax horridus</i>	*	
<i>Bathysiphon californicus</i>	*	*	<i>Reophax minutus</i>	*	*
<i>Bathysiphon discretus</i>	*	*	<i>Reophax multilocularis</i>	*	
<i>Bathysiphon varans</i>	*		<i>Reophax pilulifer</i>	*	*
<i>Bathysiphon vitta</i>	*	*	<i>Reophax splendidus</i>	*	
<i>Bigenerina cf. jurassica</i>			<i>Reophax sp.</i>	*	
<i>Dendrophyra excelsa</i>	*	*	<i>Rhabdammina cylindrica</i>	*	*
<i>Glomospira gordialis</i>	*	*	<i>Rhabdammina discreta</i>	*	*
<i>Glomospira irregularis</i>	*	*	<i>Rhabdammina latissima</i>	*	*
<i>Glomospira variabilis</i>	*		<i>Rhabdammina linearis</i>	*	*
<i>Glomospira spp.</i>	*	*	<i>Rhabdammina robusta</i>	*	*
<i>Glomospira gaultina</i>	*		<i>Rhabdammina algaeformis</i>		*
<i>Haplophragmoides decussatus</i>			<i>Rhizammina indivisa</i>	*	
<i>Haplophragmoides nonioninoides</i>	*		<i>Rzehakina sp.</i>		*
<i>Hippocrepina depressa</i>	*	*	<i>Saccamina complanata</i>	*	
<i>Hormosina crassa</i>	*		<i>Saccamina placenta</i>	*	*
<i>Hormosina excelsa</i>	*		<i>Saccamina sphaerica</i>	*	
<i>Hormosina gigantea</i>	*		<i>Saccamina spp.</i>		*
<i>Hormosina ovuloides</i>	*		<i>Sorosphaera sp.</i>	*	
<i>Hormosina ovulum</i>	*	*	<i>Spiroplectamina chicoana</i>	*	
<i>Hormosina sp.</i>	*	*	<i>Textularia sp.</i>	*	
<i>Hyperammina elongata</i>	*	*	<i>Trochamminoides spp.</i>	*	*
<i>Hyperammina gaultina</i>	*		<i>Trochamminoides conglobatus</i>	*	*
<i>Kalamopsis grzybowskii</i>	*	*	<i>Trochamminoides coronatus</i>	*	*
<i>Lagenammina sp.</i>	*		<i>Trochamminoides irregularis</i>	*	*
<i>Lituotuba irregularis</i>	*	*	<i>Trochamminoides proteus</i>	*	*
<i>Lituotuba liutiformis</i>	*	*	<i>Trochamminoides spp.</i>	*	*
<i>Lituotuba sp.</i>	*	*	<i>Uvigerinammina jankoi</i>		*
<i>Plectrorecurvoides sp.</i>	*				

foraminifera content of the examined samples (see above).

Whereas highest total abundances closely matching lowest or null carbonate values could be explained by the absence of possible dilution of the faunal content by very fine carbonate particles, the fact that also highest generic and specific diversities are found in carbonate-free or carbonate-poor samples strongly suggests that undersaturation not only allowed, but also favored the life and numerical growth of these deep-water agglutinated faunas. This observation is a working hypothesis, to be tested through further analyses of deep-water sequences.

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PALEONTOLOGICAL APPENDIX

The new suprageneric classification of Loeblich and Tappan (1984) was used. In addition to the original reference, one or few quotations are listed, which refer to the adopted species concept. Since occurrence of all taxa is quantitatively recorded in figures 2 and 3, few remarks are added. The stratigraphic distributions are based on available literature not a worldwide exhaustive documentation.

Superfamily ASTRORHIZACEA Brady 1881.

Family BATHYSIPHONINIDAE Avnimelech 1952.

Genus *Bathysiphon* Sars M. in Sars G.O. 1872.

Bathysiphon brosgiei Tappan.

1957 *Bathysiphon brosgiei*, Tappan, p. 202, pl. 65, figs. 1-5.

1962 *Bathysiphon brosgiei*, Tappan, p. 128, pl. 29, figs. 1-5.

1968 *Bathysiphon brosgiei*, Sliter, p. 40, pl., figs. 1.

Often abundant in both flysch sections. Originally described from the Middle-Late Albian of Alaska. Also found in the Late Turonian-Early Campanian of California (Trujillo 1960) and in the Albian-

Maastrichtian of California and Mexico (Sliter 1968). It is characterized by a slightly distorted tube and a smoothly finished wall.

Bathysiphon californicus Martin.

1964 *Bathysiphon californicus*, Martin, p. 43, pl. 1, fig. 2.

1968 *Bathysiphon californicus*, Sliter, p. 40, pl. 1, fig. 2.

Common at the base of the Monte Cassio section; rare and scattered in the Solignano section. Originally described from the Santonian-Maastrichtian of California. Also reported from the same locality and time-interval by Sliter (1968) and from the Late

Bathysiphon discretus Brady

Cretaceous of India (Govindan and Sastri 1983). It differs from *B. brosgiei* in having a coarsely agglutinated wall and a straight tube.

Bathysiphon discretus Brady

1881 *Rhabdammina discreta*, Brady, p. 21, fig. 48.

1981 *Bathysiphon discreta*, Gradstein and Berggren, p. 242, pl. 1, figs. 4-6, 7-10.

Rare to abundant in both sections. Originally described from sediments of the North Atlantic Ocean. Also reported from the Maastrichtian to Paleogene of the Labrador Shelf and North Sea (Gradstein and Berggren 1981). Both var. A and B. of Gradstein and Berggren were found.

Bathysiphon varans Sliter

1968 *Bathysiphon varans*, Sliter, p. 40, pl. 1, fig. 4.

Rare in two samples from the Solignano Flysch. Originally described from the Campanian-Maastrichtian of California and Mexico. It differs from *B. vitta* in having smaller diameter, numerous constrictions, coarser agglutinated material and rougher surface.

Bathysiphon vitta Nauss

1947 *Bathysiphon vitta*, Nauss, p. 334, pl. 48, fig. 4.

1960 *Bathysiphon vitta*, Trujillo, p. 302, pl. 43, fig. 2.

1968 *Bathysiphon vitta*, Sliter, p. 40, pl. 1, fig. 3.

1981 *Bathysiphon vitta*, Butt, p. 111, pl. 15, fig. K.

Fairly abundant in both sections. Originally described from the Late Cretaceous of Canada. Also reported from the Middle Turonian-Santonian of California (Trujillo 1960), from the Albian-Maastrichtian of California and Mexico (Sliter 1968), and from the Late Cretaceous of the Eastern Alps (Butt 1981). It is characterized by large-sized parallel-sided chambers, and finely agglutinated and smooth wall.

Family RHIZAMMINIDAE Rhumbler 1895
Genus *Rhabdammina* Sars in Carpenter 1869

Rhabdammina cylindrica Glaessner

1937 *Rhabdammina cylindrica*, Glaessner, p. 354, pl. 1, fig. 1.

1977 *Psammosiphonella cylindrica*, Krasheninnikov and Pflaumann, p. 573, pl. 1, fig. 12.

1981 *Rhabdammina cylindrica*, Butt, pl. 111, pl. 15, fig. E.

Always present and abundant in both sequences. Originally described from the Paleogene of Caucasus. Also found in the Late Cretaceous of the eastern north Atlantic (Krasheninnikov and Pflaumann 1977), in the Late Cretaceous of the eastern Alps (Butt 1981), in the Late Cretaceous to Late Eocene of the Polish Carpathians (Morgiel and Olszewska 1981) and in the Eocene of the Norwegian-Greenland Sea (Verdenius and Van Hinte 1983). It differs from *R. discreta* in having a smaller length/width ratio of the test.

Rhabdammina discreta Brady

1881 *Rhabdammina discreta*, Brady, p. 39, pl. 1, fig. 3.

1981 *Rhabdammina discreta*, Butt, p. 111, pl. 15, fig. A.

A single peak of extreme abundance in both sequences. Originally described from recent sediments of the northern Atlantic Ocean. Also found in the Late Cretaceous of the northern Apennines (Montanaro Gallitelli 1943) and of the eastern Alps (Butt 1981) and in the Late Cretaceous to Eocene of the Polish Carpathians (Morgiel and Olszewska 1981). It differs from *Bathysiphon discretus* in showing an initial branching of the arms.

Rhabdammina latissima (Grzybowski)

1898 *Dendrophrya latissima*, Grzybowski, p. 271, pl. 10, fig. 8.

1981 *Rhabdammina latissima*, Butt, p. 111, pl. 16, fig. F.

Abundant in both sections. Originally described from the Paleogene of Poland. Also reported from the Late Cretaceous of the eastern Alps (Butt 1981).

Rhabdammina linearis Brady

1879 *Rhabdammina linearis*, Brady, p. 37, pl. 3, figs. 10, 11.

1981 *Rhabdammina linearis*, Butt, 1981, p. 111, pl. 15, figs. B-D.

Common in the upper part of the Monte Cassio section; rare in a sample from the Solignano section. Originally described from recent oceanic sediments. Also found in the Late Cretaceous of the eastern Alps (Butt 1981). It differs from *R. discreta* because it shows some annular constrictions.

Rhabdammina robusta (Grzybowski)

1898 *Dendrophrya robusta*, Grzybowski, p. 273, pl. 10, fig. 7.

1981 *Rhabdammina robusta*, Butt, p. 111, pl. 15, figs. H, H₁.

Abundant in the Monte Cassio Flysch, common to abundant in the Solignano Flysch. Originally described from the Paleogene of Poland. Also found in the Late Cretaceous of the eastern Alps (Butt 1981).

Genus *Rhizammina* Brady 1879

Rhizammina algaeformis Brady

1879 *Rhizammina algaeformis*, Brady, p. 20, pl. 4, figs. 16, 17.

1977 *Rhizammina algaeformis*, Krasheninnikov and Pflaumann, p. 573, pl. 1, fig. 5.

Scarce to common only in the Monte Cassio Flysch. Originally described from recent oceanic sediments. Also reported from the Late Cretaceous of the eastern North Atlantic (Krasheninnikov and Pflaumann 1977) and of the western Central Atlantic (Hemleben and Troester 1984, as *ex gr.*). It differs from *R. indivisa* in showing a major length/width ratio of the test and a more finely agglutinated wall.

Rhizammina indivisa Brady

1884 *Rhizammina indivisa*, Brady, p. 277, pl. 29, figs. 5-7.

1981 *Rhizammina indivisa*, Gradstein and Berggren, p. 242, pl. 1, figs. 1-3.

Abundant in both sections. Originally described from recent sediments of the Faroe Channel. Also found in the Early Cretaceous of the eastern North Atlantic (Sliter 1980), the Polish Carpathians (Morgiel and Olszewska 1981) and the Paleogene of the North Sea (Gradstein and Berggren 1981).

Dendrophrya excelsa Grzybowski

1897 *Dendrophrya excelsa*, Grzybowski, p. 272, pl. 10, figs. 1-4.

1977 *Dendrophrya excelsa*, Krasheninnikov and Pflaumann, p. 573, pl. 1, figs. 6, 7.

1981 *Dendrophrya excelsa*, Butt, p. 111, pl. 15, fig. 6.

Rare in the Monte Cassio Flysch; rare to common in the Solignano Flysch. Originally described from the Paleogene of Poland. Also reported from the Late Cretaceous of the Carpathians and Alpine Flysch (Hanzlikova 1973), the eastern Alps (Butt 1981) and the eastern North Atlantic (Krasheninnikov and Pflaumann 1977), from the Late Cretaceous to Paleogene of the Polish Carpathians (Morgiel and Olszewska 1981) and from the Eocene-Oligocene of the Norwegian-Greenland Sea (Verdenius and Van Hinte 1983).

Family SACCAMMINIDAE Brady 1884
Genus *Saccamina* Sars in Carpenter 1869

Saccamina complanata (Franke)

1912 *Pelosina complanata*, Franke, p. 107, pl. 3, fig. 1

1974 *Pelosina complanata*, Krasheninnikov, p. 661, pl. 7, figs. 10a, b.

Rare in a sample from the lower part of the Solignano Flysch. Originally described from the Eocene of Germany. Also found in the Cenomanian-Turonian of Japan (Takayanagi 1960), and in the Upper Cretaceous of California and Mexico (Sliter 1968), the northeastern Indian Ocean (Krasheninnikov 1974) the eastern North Atlantic (Krasheninnikov and Pflaumann 1977), and of the western South Atlantic (Sliter 1977), in the Early Eocene of the Labrador Sea (Miller *et al.* 1982), in the Aptian of England (Crittenden 1983) and in the Paleocene of Poland (Jednorowska and Pozaryska 1983).

Saccamina placenta (Grzybowski)

1898 *Reophax placenta*, Grzybowski, p. 276, pl. 10, figs. 9, 10.

1977 *Saccamina placenta*, Krasheninnikov and Pflaumann, p. 573, pl. 1, fig. 16.

1981 *Saccamina placenta*, Butt, p. 113, pl. 16, fig. E.

Rare in two samples from the Monte Cassio Flysch and rare to abundant in the Solignano Flysch. Originally described from the latest Eocene of Poland. Also reported from the Late Cretaceous of the eastern North Atlantic (Krasheninnikov and Pflaumann 1977) and the eastern Alps (Butt 1981), from the Cretaceous to Paleogene of the Polish Carpathians (Morgiel and Olszewska 1981), from the Early Maastrichtian-Paleocene of northern Italy (Beckmann *et al.* 1982) and from the Oligocene of the Norwegian-Greenland and Sea (Verdenius and Van Hinte 1983).

Saccamina sphaerica Sars

1872 *Saccamina sphaerica*, Sars, p. 532, fig. 272.

1981 *Saccamina sphaerica*, Gradstein and Berggren, p. 244, pl. 2, figs. 4-6.

Rare in a sample from the Solignano Flysch. Originally described from recent sediments of Norway fjords. Also found in the Late Cretaceous to Paleogene of the Labrador Shelf and North Sea (Gradstein and Berggren 1981) and in the Late Cretaceous of the western Central Atlantic (Hemleben and Troester 1984). It differs from *S. complanata* in having a more coarsely agglutinated surface.

Saccamina spp.

Rare and unidentifiable specimens from a sample of the Monte Cassio Flysch.

Genus *Sorosphaera* Brady 1879

Sorosphaera sp.

Rare in a sample from the Solignano Flysch.

Genus *Lagenamma* Rhumbler 1911

Lagenamma sp.

Rare specimens from a basal sample of the Solignano Flysch; very similar in overall characters to *Lagenamma* sp. 2 of Crittenden 1983.

Superfamily HYPERAMMINACEA,

Eimer and Fickert 1899

Family HYPERAMMINIDAE Eimer and Fickert

Genus *Hippocrepina* Parker in Dawson 1870

Hippocrepina depressa Vasicek

1947 *Hippocrepina depressa*, Vasicek, p. 243, pl. 1, figs. 1, 2.

1981 *Hippocrepina depressa*, Morgiel and Olszewska, p. 11, pl. 1, figs. 3, 4.

Common to abundant in the Monte Cassio samples, and common in the Solignano samples. Originally described from the Cretaceous of Moravia. Also found in the Early Cretaceous (Hauterivian to Cenomanian) of the Polish Carpathians (Morgiel and Olszewska 1981) and in the Oligocene of the Norwegian-Greenland Sea (Verdenius and Van Hinte 1983, as *H. cf. depressa*).

Genus *Hyperamma* Brady 1879

Hyperamma elongata Brady

1879 *Hyperamma elongata*, Brady, p. 433, pl. 20, fig. 2.

1974 *Hyperamma elongata*, Krasheninnikov, p. 661, pl. 7, figs. 13-14.

1983 *Hyperamma elongata*, Basov and Krasheninnikov, p. 774, pl. 4, fig. 9.

Rare in the Solignano Flysch, rare in one sample from the Monte Cassio Flysch. Originally described from recent oceanic sediments. Also reported from the Late Cretaceous of the northern Pacific (Krasheninnikov 1974, as *ex gr.*), from the Turonian-Earliest Campanian of the southwestern Atlantic (Basov and Krasheninnikov 1983) and from the Late Cretaceous of the western Central Atlantic (Hemleben and Troester 1984, as *ex gr.*).

Hyperamma gaultina Ten Dam

1950 *Hyperamma gaultina*, TenDam, p. 5, pl. 1, fig. 8.

1977 *Hyperamma gaultina*, Krasheninnikov and Pflaumann, p. 573, pl. 1, figs. 10-11.

Rare to common in the Solignano Flysch. Originally described from the Albian of the Netherlands. Also found in the Late Cretaceous of the eastern North Atlantic (Krasheninnikov and Pflaumann 1977) and in the Early Cretaceous of the eastern North Atlantic (Sliter 1980).

Superfamily AMMODISCACEA Reuss 1862

Family AMMODISCIDAE Reuss 1862

Genus *Ammodiscus* Reuss 1862

Ammodiscus cretacea (Reuss)

1845 *Operculina cretacea*, Reuss, p. 35, pl. 13, figs. 64, 65

1981 *Operculina cretacea*, Gradstein and Berggren, p. 244, pl. 2, figs. 12-13.

Rare in the Monte Cassio Flysch and rare in two samples from the Solignano Flysch. Originally described from the Late Cretaceous of Bohemia. Also found in the Albian to Early Cenomanian of Japan (Takayanagi 1960), in the Campanian of Alaska and of California (Graham and Church 1963), in the Late Cretaceous of California and Mexico (Sliter 1968), of the Indian Ocean (Krasheninnikov 1974), of the western South Atlantic (Sliter 1977), in the late Cretaceous to Paleogene of the Labrador Shelf and the North Sea (Gradstein and Berggren 1981); in the Eocene of the Labrador Sea (Miller *et al.* 1982), in the Early Maastrichtian of northern Italy (Beckmann *et al.* 1982), in the Aptian of England (Crittenden 1983), and in the Late Cretaceous of India (Govindan and Sastri 1983), of the southwestern Atlantic (Basov and Krasheninnikov 1983) and of the western Central Atlantic (Hemleben and Troester 1984).

Ammodiscus pennyi Cushman and Jarvis

1928 *Ammodiscus pennyi*, Cushman and Jarvis, p. 37, pl. 12, figs. 4-5.

1977 *Ammodiscus pennyi*, Krasheninnikov and Pflaumann, p. 576, pl. 2, figs. 10-11.

Rare in the upper part of the Solignano section. Originally described from the Paleocene of Trinidad. Also reported from the Cretaceous of the eastern North Atlantic (Krasheninnikov and Pflaumann 1977).

Ammodiscus peruvianus Berry

1928 *Ammodiscus peruvianus*, Berry, p. 342, pl. 27.

1981 *Ammodiscus peruvianus*, Gradstein and Berggren, p. 244, pl. 2, figs. 14, 15.

Rare in the lower-middle part of the Solignano section. Originally described from the Late Eocene of northwestern Peru. Also found in the Campanian to Maastrichtian of western Greenland and Campanian to Paleogene of Labrador Shelf and central North Sea (Gradstein and Berggren 1981).

Ammodiscus cf. tenuis Brady

1881 *Ammodiscus tenuis*, Brady, p. 51, figs. 4-6.

1981 *Ammodiscus cf. tenuis*, Butt, p. 111, pl. 15, fig. 0.

Specimens from a sample of the Solignano Flysch, are similar to those figured by Butt (1981). It also occurs in the Upper Cretaceous of the eastern Alps (Butt 1981).

Genus *Glomospira* Rzehak 1895

Glomospira gordialis (Jones and Parker)

1860 *Trochammina squamata* var. *gordialis*, Jones and Parker, p. 304.

1977 *Glomospira gordialis*, Sliter, p. 678, pl. 1, fig. 7.

1981 *Glomospira gordialis*, Butt, p. 111, pl. 15, fig. 0.

Usually rare and scattered in both sections. Originally described from recent sediments of Indian and Arctic Oceans. Also found in the Late Cretaceous of the northern Apennines (Montanaro Gallitelli 1943), in the Cretaceous in the western South Atlantic (Sliter 1977), in the Late Cretaceous of the eastern North Atlantic (Krasheninnikov and Pflaumann 1977), in the "Tithonian" to Oligocene of the Polish Carpathians (Morgiel and Olszewska 1981), in the Late Cretaceous and Paleocene of the Labrador Shelf and North Sea (Gradstein and Berggren 1981) and of the eastern Alps (Butt 1981), in the Paleogene of northern Italy (Beckmann *et al.* 1982), in the Eocene of the Labrador Sea (Miller *et al.* 1982), and in the Late Cretaceous of the southwestern Atlantic (Basov and Krasheninnikov 1983) and of the western Central Atlantic (Hemleben and Troester 1984).

Glomospira irregularis (Grzybowski)

1898 *Ammodiscus irregularis*, Grzybowski, p. 285, pl. 11, figs. 2-3.

1981 *Glomospira irregularis*, Gradstein and Berggren, p. 245, pl. 3, figs. R-U.

Rare in both sections with a peak of abundance in the uppermost sample of the Monte Cassio section. First described from the latest Eocene of Poland. Also reported from the Maastrichtian to Eocene of the Labrador Shelf and the North Sea (Gradstein and Berggren 1981), from the Cretaceous to Paleogene of the Polish Carpathians (Morgiel and Olszewska 1981), from the Paleogene of northern Italy (Beckman *et al.* 1982), from the Eocene of the Labrador Sea (Miller *et al.* 1982) and from the Late Cretaceous of the western Central Atlantic (Hemleben and Troester 1984).

Glomospira variabilis (Kubler and Swingli)

1870 *Cornuspira variabilis*, Kubler and Swingli, p. 33, pl. 4(I), figs. 4a, b.

1980 *Cornuspira variabilis*, Sliter, p. 373, pl. 1, figs. 9-10.

Rare in three samples from the Solignano Flysch. Originally described from the German Jura. Also found in the Early Cretaceous of the eastern Atlantic (Sliter 1980).

Genus *Glomospirella* Plummer 1945

Glomospirella gaultina (Berthelin)

1880 *Ammodiscus gaultinus*, Berthelin, p. 19, fig. 3.

1974 *Glomospirella gaultina*, Krasheninnikov, p. 661, pl. 7, figs. 6, 7.

Rare only in the Solignano Flysch. Originally described from the Albian of France. Also reported from the Late Cretaceous of the North Pacific (Krasheninnikov 1973), from the Early Cretaceous (Albian) to Late Cretaceous of the Indian Ocean (Krasheninnikov 1974), from the Late Cretaceous of the eastern North Atlantic (Krasheninnikov and Pflaumann 1977) and of the southwestern Atlantic (Basov and Krasheninnikov 1983) and from the Aptian of England (CRITTENDEN 1983).

Superfamily RZEHAKINACEA Cushman 1933

Family RZEHAKINIDAE, Cushman 1933

Genus *Rzehakina* Cushman 1923

Rzehakina sp.

Rare, distorted specimens tentatively assigned to the genus occur in the lowermost sample of the Monte Cassio section.

Superfamily HORMOSINACEA Haeckel 1894

Family HORMOSINIDAE, Haeckel 1894

Genus *Hormosina*, Brady 1879

Hormosina crassa Geroch

1966 *Hormosina ovulum crassa*, Geroch, p. 439, pl. 6, figs. 19-21, 26, pl. 7, figs. 21-23.

1984 *Hormosina ovulum crassa*, Hemleben and Troester, p. 520, pl. 2, fig. 8.

Rare in one sample from the lower part of the Solignano section. Originally described from the Paleogene of Poland. Also found in the Late Cretaceous of the North Pacific (Krasheninnikov 1973), in the Barremian to Early Senonian of the Polish Carpathians (Morgiel and Olszewska 1981) and in the Late Cretaceous of the western North Atlantic (Hemleben and Troester 1984).

Hormosina excelsa (Dylazanka)

1923 *Hyperammia excelsa*, Dylazanka, p. 66, pl. 1, fig. 3.

1981 *Hormosina excelsa*, Morgiel and Olszewska, p. 13, pl. 2, figs. 6-7.

Rare in the Solignano section. Originally described from the Cretaceous of Poland. Also found in the Late Senonian to Earliest Eocene of the Polish Carpathians (Morgiel and Olszewska 1981), in the Paleogene of Poland (Jednorowska and Pozaryska 1983) and in the Eocene and Oligocene of the Norwegian-Greenland Sea (Verdenius and Van Hinte 1983).

Hormosina gigantea Geroch

1960 *Hormosina ovulum gigantea*, Geroch, P. 43, pl. 2, figs. 18, 19.

1981 *Hormosina gigantea*, Morgiel and Olszewska, p. 13, pl. 2, fig. 8.

Rare in a sample from the upper part of the Solignano section. Originally described from the

Paleocene of Poland. Also found in the Senonian of the Polish Carpathians (Morgiel and Olszewska 1981) and in the Paleocene of Poland (Jednorowska and Pozaryska 1983).

Hormosina ovuloides Grzybowski

1901 *Reophax ovuloides*, Grzybowski, pl. 8, figs. 19, 21.

1981 *Hormosina (Pelosina) ovuloides*, Butt, p. 113, pl. 16, figs. C, C₁.

Rare in a sample from the upper part of the Solignano Flysch. Originally described from the Cretaceous of Carpathians. Also reported from the Late Cretaceous of the western Alps (Butt 1981) and of the western Central Atlantic (Hemleben and Troester 1984).

Hormosina ovulum (Grzybowski)

1897 *Reophax ovulum*, Grzybowski, p. 276.

1977 *Hormosina ovulum*, Krasheninnikov and Pflaumann, p. 573, pl. 1, figs. 17-18.

Rare to common in the upper part of the Solignano section and in the middle and upper part of the Monte Cassio section, with a peak of abundance in the uppermost sample. Originally described from the Campanian of Poland. Also found in the Late Cretaceous of the North Pacific (Krasheninnikov and Pflaumann 1977), in the Cretaceous to Paleogene of the Polish Carpathians (Morgiel and Olszewska 1981), in the Late Cretaceous of the Labrador Shelf (Gradstein and Berggren 1981), in the Paleogene of the Northern Italy (Beckamnn *et al.* 1982) and of Poland (Jednorowska and Pozaryska 1983) and in the Late Cretaceous of the western Central Atlantic (Hemleben and Troester 1984).

Hormosina sp.

Rare, crushed specimens from two samples of the Solignano section and rare specimens from the uppermost sample of the Monte Cassio section.

Genus *Kalamopsis* De Folin 1883

Kalamopsis grzybowski (Dylazanka)

1923 *Hyperammia grzybowski*, Dylazanka, p. 65

1977 *Kalamopsis grzybowski*, Krasheninnikov and Pflaumann, p. 573, pl. 1, fig. 13.

1981 *Kalamopsis grzybowski*, Morgiel and Olszewska, p. 13, pl. 2, fig. 4.

1981 *Kalamopsis grzybowski*, Butt, p. 111, pl. 15, figs. L, L₁.

Rare in a sample from the Monte Cassio Flysch and rare to common in three samples from the Solignano Flysch. Originally described from the Cretaceous of Poland. Also reported from the Late Cretaceous of the eastern North Atlantic (Krasheninnikov and Pflaumann 1977) and of the eastern Alps (Butt 1981), from the Late Cretaceous to Eocene of the Polish Carpathians (Morgiel and Olszewska 1981), from the Paleocene of Poland (Jednorowska and

Pozaryska 1983) and from the Late Cretaceous of the western Central Atlantic (Hemleben and Troester 1984).

Genus *Reophax* Montfort 1808

Reophax duplex Grzybowski

1897 *Reophax duplex*, Grzybowski, p. 276, pl. 8, figs. 23-25.

1981 *Reophax duplex*, Gradstein and Berggren, p. 244, pl. 2, fig. 7.

1981 *Reophax duplex*, Butt, p. 113, pl. 16, fig. 3

Rare in the lower part of the Solignano section. Originally described from the Campanian of Poland. Also found in the Late Cretaceous of the eastern Alps (Butt 1981), in the Maastrichtian to Eocene of the Labrador Shelf and North Sea (Gradstein and Berggren 1981) and in the Early Maastrichtian to Paleocene of northern Italy (Beckmann *et al.* 1982).

Reophax elongatus Grzybowski

1898 *Reophax duplex*, Grzybowski, p. 279, pl. 10, figs. 19-20.

1981 *Reophax elongatus*, Morgiel and Olszewska, p. 13, pl. 2, figs. 11.

Rare in a sample from the Solignano section. Originally described from the Paleogene of Poland. Also found in the Eocene of the Polish Carpathians (Morgiel and Olszewska 1981).

Reophax horridus (Schwager)

1865 *Haplostiche horrida*, Schwager, p. 92, pl. 2, figs. 2a,c.

1980 *Reophax horridus*, Sliter, p. 373, pl. 1, fig. 17.

Rare in a sample from the Solignano Flysch. Originally described from the Jurassic of Germany. Also found in the Early Cretaceous of the Eastern North Atlantic (Sliter 1980).

Reophax minutus Tappan

1940 *Reophax minutus*, Tappan, p. 94, pl. 14, fig. 3.

1981 *Reophax minutus*, Butt, p. 113, pl. 16, fig. O.

1981 *Reophax minutus*, Morgiel and Olszewska, p. 13, pl. 2, figs. 5

Rare in the Solignano Flysch, rare in a sample from the Monte Cassio Flysch. Originally described from the Cretaceous of Texas. Also reported from the Early Cretaceous of the eastern North Atlantic (Sliter 1980), from the Late Cretaceous of the eastern Alps (Butt 1981), from the Barremian-Turonian of the Polish Carpathians (Morgiel and Olszewska 1981) and from the Aptian of England (Crittenden 1983).

Reophax multilocularis Haeusler

1883 *Reophax multilocularis*, Haeusler, "not shown" in Ellis and Messina, 1940.

1980 *Reophax multilocularis*, Sliter, p. 373, pl. 1, fig. 19.

Rare specimens from the base of the Solignano Flysch. It also occurs in the Lower Cretaceous of the eastern North Atlantic (Sliter 1980).

Reophax pilulifer Brady

1884 *Reophax pilulifera*, Brady, p. 292, pl. 30, figs. 18-20.

1981 *Reophax pilulifer*, Morgiel and Olszewska, pl. 13, pl. 2, fig. 10.

1981 *Reophax pilulifer*, Gradstein and Berggren, p. 244, pl. 2, figs. 10, 11.

Rare in the Solignano Flysch and rare in a sample from the Monte Cassio Flysch. Originally described from recent sediments of the North Atlantic Ocean. Also reported from the Late Cretaceous of the eastern North Atlantic (Krasheninnikov and Pflaumann 1977), from the Early Cretaceous of the eastern North Atlantic (Sliter 1980), from the Late Cretaceous to Eocene of the Polish Carpathians (Morgiel and Olszewska 1981), from the Late Cretaceous to Eocene of the Labrador Shelf and North Sea (Gradstein and Berggren 1981) and from the Eocene of Labrador Sea (Miller *et al.* 1982).

Reophax splendidus, Grzybowski

1897 *Reophax splendidus*, Grzybowski, p. 278, pl. 10, fig. 16.

1981 *Reophax splendidus*, Butt, p. 113, pl. 16, fig. N. Rare in the Solignano section. Originally described from the Cretaceous of Poland. Also found in the Late Cretaceous of the eastern Alps (Butt 1981).

Reophax sp.

Rare to common broken and/or heavily encrusted specimens in the Solignano section.

Superfamily LITUOLACEA De Blainville 1825

Family HAPLOPHRAGMOIDIDAE Maync 1952

Genus *Haplophragmoides* Cushman 1910

Haplophragmoides decussatus, Krasheninnikov

1973 *Haplophragmoides decussatus*, Krasheninnikov, p. 208, pl. 2, figs. 3a, b.

1974 *Haplophragmoides decussatus*, Krasheninnikov, p. 649, pl. 1, figs. 6a, b.

Two specimens from a sample of the upper part of the Solignano section. Originally described from the Late Cretaceous of the North Pacific. Also reported from the Late Turonian-Coniacian of the Northeastern Indian Ocean (Krasheninnikov 1974).

Haplophragmoides nonioninoides (Reuss)

1863 *Haplophragmium nonioninoides*, Reuss, p. 30, pl. 1, fig. 8.

1980 *Haplophragmoides nonioninoides*, Sliter, p. 375, pl. 2, figs. 5-6.

1981 *Haplophragmoides nonioninoides*, Morgiel and Olszewska, p. 13, pl. 2, fig. 16.

Rare in a sample from the middle part of the Solignano section. Originally described from northern Germany. Also found in the Early Cretaceous of the eastern North Atlantic (Sliter 1980), in the Barremian to Albian of the Polish Carpathians (Morgiel and Olszewska 1981) and in the Aptian of England (Crittenden 1983).

Genus *Trochamminoides* Cushman 1910

Trochamminoides conglobatus (Brady)

1884 *Trochammina conglobata*, Brady, p. 494, pl. 1, fig. 7.

1981 *Trochamminoides conglobatus*, Butt, p. 113, pl. 16, figs. R, S.

Rare in both sections. Originally described from recent oceanic sediments. Also found in the Late Cretaceous of the eastern Alps (Butt 1981) and of the western North Atlantic (Hemleben and Troester 1984).

Trochamminoides coronatus (Brady)

1879 *Trochammina coronata*, Brady, p. 78, pl. 5, fig. 15.

1981 *Trochamminoides coronatus*, Morgiel and Olszewska, p. 15, pl. 3, fig. 2.

1981 *Trochamminoides coronatus*, Butt, p. 113, pl. 16, fig. Q.

Rare in the Solignano Flysch, common in a sample from the base of the Monte Cassio Flysch. Originally described from ocean-floor dredge samples. Also reported from the Late Cretaceous of the eastern North Atlantic (Krasheninnikov and Pflaumann 1977) and of the eastern Alps (Butt 1981), from the Late Cretaceous to Eocene of the Polish Carpathians (Morgiel and Olszewska 1981), from the Paleocene-Eocene of the Labrador Shelf and North Sea (Gradstein and Berggren 1981), from the Early Maastrichtian to Paleocene of northern Italy (Beckmann *et al.* 1982) and from the Late Cretaceous of the western Central Atlantic (Hemleben and Troester 1984).

Trochamminoides irregularis White

1928 *Trochamminoides irregularis*, White, p. 307, pl. 42, fig. 1

1981 *Trochamminoides irregularis*, Morgiel and Olszewska, p. 15, pl. 3, fig. 4.

Rare in both sections. Originally described from the Late Cretaceous of Mexico. Also found in the Late Cretaceous to Eocene of the Polish Carpathians (Morgiel and Olszewska 1981).

Trochamminoides proteus (Karrer)

1865 *Trochamminoides proteus*, Karrer, p. 494, pl. 1, fig. 8.

1881 *Trochamminoides proteus*, Butt, p. 113, pl. 16, fig. P.

1981 *Trochamminoides proteus*, Morgiel and Olszewska, p. 15, pl. 3, fig. 11.

Rare in the Solignano section and rare in the Monte Cassio section. Originally described from the Cretaceous of Austria. Also reported from the Late Cretaceous to Paleocene of the Polish Carpathians (Morgiel and Olszewska 1981).

Trochamminoides spp.

Crushed, distorted and badly preserved specimens tentatively assigned to the genus; rare in a sample from the base of the Monte Cassio Flysch and in a sample from the middle part of the Solignano Flysch.

Family LITUOTUBIDAE

Loeblich and Tappan 1984.

Genus *Lituotuba* Rumbler 1895.

Lituotuba irregularis Tappan

1955 *Lituotuba irregularis*, Tappan, p. 41, pl. 9, figs. 5-9.

Common to rare in the Solignano Flysch and rare in the Monte Cassio Flysch. Originally described from the Early Jurassic of northern Alaska. (Also reported from the Late Cretaceous as *L. incerta* (Bartenstein and Brand 1937).

Lituotuba lituiformis (Brady)

1884 *Trochamminoides lituiformis*, Brady, pl. 40, figs. 5-7.

1981 *Lituotuba lituiformis*, Butt, p. 113, pl. 16, fig. T
Rare in a sample from the Monte Cassio Flysch; rare in the Solignano Flysch. Originally described from recent oceanic sediments. Also found in recent sediments (Loeblich and Tappan 1964) and in the Late Cretaceous of the eastern Alps (Butt 1981).

Lituotuba sp.

Rare to common, specimens in both sections.

Family AMMOSPHAERIODINIDAE Cushman 1927

Genus *Recurvoides* Earland 1934

Recurvoides contortus Earland

1934 *Recurvoides contortus*, Earland, p. 91, pl. 3, figs. 11-12.

1981 *Recurvoides contortus*, Morgiel and Olszewska, p. 15, pl. 3, figs. 5-6.

Rare from a sample of the middle part of Solignano section. Originally described from recent sediments of the Antarctic Ocean. Also reported from the Cretaceous to Eocene of the Polish Carpathians.

Superfamily SPIROPLECTAMMINACEA

Cushman 1927

Family SPIROPLECTAMMINIDAE Cushman 1927

Genus *Spiroplectammina* Cushman 1927

Spiroplectammina chicoana Lalicker

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

1960 *Spiroplectamina chicoana*, Trujillo, p. 297, pl. 44, figs. 6a, b.

1968 *Spiroplectamina chicoana*, Sliter, p. 41, pl. 2, figs. 8a, b.

1978 *Spiroplectamina chicoana*, Beckman, p. 773, pl. 1, fig. 3.

Rare specimens from the base of the Solignano Flysch. Originally described from the Cretaceous of California. Also reported from the Late Coniacian-Santonian of California (Trujillo 1960) and of California and Mexico (Sliter 1978), and from the Late Cretaceous of the southern Atlantic Ocean (Beckman 1978).

Superfamily TROCHAMMINACEA Schwager 1877

Family TROCHAMMINIDAE Schwager 1877

Genus *Trochammina* Parker and Jones 1859.

Trochammina spp.

Rare, badly preserved and distorted specimens in both sections.

Superfamily VERNEULINACEA Cushman 1911

Family VERNEULINIDAE Cushman 1911

Genus *Uvigerinammina*, Majzon 1943

Uvigerinammina jankoi Majzon

1943 *Uvigerinammina jankoi*, Majzon, p. 158, pl. 2, figs. 15.

1974 *Uvigerinammina jankoi* Krasheninnikov, p. 642, pl. 6, figs. 9a, b-10a.

1977 *Uvigerinammina jankoi* Krasheninnikov and Pflaumann, p. 569, figs. 12, 13.

1981 *Uvigerinammina jankoi* Gradstein and Berggren, p. 249, pl. V, figs. 10-12.

Rare specimens from a sample of the Monte Cassio Flysch. Originally described from Cretaceous-(?) Paleogene flysch sediments of Poland. Also found in the Late Turonian-Coniacian of the northeastern Indian Ocean (Krasheninnikov 1974), in the Late Cretaceous of the Eastern North Atlantic (Krasheninnikov and Pflaumann 1977) and of the Labrador Shelf (Gradstein and Berggren 1981), in the Late Albian of the southwestern Atlantic (Basov and Krasheninnikov 1983), and in the Late Cretaceous of the western Central Atlantic (Hemleben and Troester 1984).

Family PLECTORECURVOIDIDAE

Loeblich and Tappan 1964

Genus *Plectorecurvoides* Noth 1952.

Plectorecurvoides sp.

Rare specimens from a sample of the uppermost part of the Solignano Flysch.

Family PSEUDOBOLIVINIDAE Wiesner 1931.

Genus *Pseudobolivina* Wiesner 1931.

Pseudobolivina munda Krasheninnikov

1973 *Pseudobolivina munda*, Krasheninnikov, p. 210, pl. 2, figs. 10-11.

1974 *Pseudobolivina munda*, Krasheninnikov, p. 665, pl. 4, figs. 6a, b-7a.

Rare specimens from the lower part of the Solignano section. Originally described from the Late Cretaceous of the North Pacific. Also found in the Late Cretaceous of the Indian Ocean (Krasheninnikov 1974).

Pseudobolivina normalis Krasheninnikov

1974 *Pseudobolivina normalis*, Krasheninnikov, p. 655, pl. 4, figs. 10a, b.

Rare specimens from the middle part of the Solignano section. Originally described from the Late Cretaceous of the Indian Ocean.

Superfamily ATAXOPHRAGMIACEA

Schwager 1877

Family GLOBOTEXTULARIIDAE Cushman 1927

Genus *Arenobulimina* Cushman 1927.

Arenobulimina sp.

Rare, encrusted specimens from a sample of the Solignano Flysch, tentatively assigned to the genus.

Superfamily TEXTULARIACEA Ehrenberg 1839

Family TEXTULARIIDAE Ehrenberg 1839.

Genus *Textularia* Defrance 1824.

Textularia sp.

Rare to common, crushed and badly preserved specimens from the Solignano Flysch.

Genus *Bigenerina* d'Orbigny 1826.

Bigenerina cf. *jurassica* (Haeusler)

1890 *Pleurostomella jurassica*, Haeusler, p. 77, pl. 12, figs. 14-22.

1980 *Bigenerina jurassica*, Sliter, p. 377, pl. 3, figs. 8-10.

Rare specimens from the base of the Solignano section. Also described from the Upper Jurassic of the eastern North Atlantic (Sliter 1980)

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