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Flyschoid deposits of Goriška Brda (Collio) between Soča (Isonzo) River and Idrija (Iudrio) River – facies and paleoenvironments

I depositi flyschoidi dei Colli Goriziani (Goriška Brda) tra il fiume Isonzo (Soča) e fiume Iudrio (Idrija) – facies e condizioni paleoecologiche

Flišoidni sedimenti iz Goriških Brd med Sočo in Idrijo – faciesi in paleoekološke razmere

Giorgio Tunis

Istituto di Geologia e Paleontologia dell'Università degli studi
Piazzale Europa 1, 34127 Trieste, (Italia)

Camilla Pirini Radrizzani

Istituto di Geologia dell'Università di Genova
Corso Europa 30, 16132 Genova, (Italia)

Abstract

Presented is the interpretation of environments of main facies associations types in Goriška Brda. The high diversity of studied depositional facies bears evidence of profound differences of environments during deposition of flyschoid beds. Environments from relatively deep sea to those of the external margin of the platform, and those of delta (delta front and delta plain) can be established.

Riassunto

Viene qui fornita l'interpretazione ambientale delle principali associazioni di facies riconosciute nel Collio. La grande varietà delle facios sedimentarie esaminate testimonia una altrettanto varia diversificazione ambientale dei depositi flyschoidi del Collio. Si è riscontrata un'evoluzione da condizioni di ambiente marino relativamente profondo, ad ambiente di piattaforma esterna ed interna, ad ambiente di delta (fronte deltizio e piana deltizia).

Kratka vsebina

Podana je razlaga okolja ob nastajanju osnovnih tipov faciesov v Goriških Brdih. Velika raznolikost preučevanih sedimentacijskih faciesov kaže na velike razlike v okolju med nastajanjem flišoidnih kamnin. Opazujemo razvoje od relativno globokega morja do zunanjega roba platforme in do delte (čelo delte in prodelta).

Introduction

The area under examination is situated between the Soča (Isonzo) River and the Idrija (Iudrio) River and straddles the Italian – Yugoslav border; specifically it lies between Korada (Corada), Medeja (Mt. Medea) and Sabotin (Mt. Sabotino). The outcrops of this area are mainly represented by Tertiary clastic sediments ranging in age from Early Ilerdian (Cimerman et al., 1974) to Early Lutetian.

Older deposits obviously outcrop here. An example are the Podsabotin beds (Campanian-Maastrichtian – Early Eocene), situated in the south-eastern sector near Sabotin (see Šribar, 1966; Pavšič, 1977 and 1979). Near Kožbana, both on the southwestern side of the Cretaceous anticline (Cousin, 1981) and on the northeastern flank (Cimerman et al., 1974) there is a flysch rich in conglomerates dating back to the Late Thanetian. As far as younger beds are concerned, Cousin (1981) also reports the presence of Biarritzian in two outcrops, one near Subida (Cormons) and the other near Ponte del Torrione (Gorizia).

This paper will deal mostly with the flyschoid sediments lying above the olistostrome of Plave which could correspond chronologically to the "Megastrato di M. Ioanaz", as we have defined it in the subdivision of flyschoid units in eastern Friuli (Pirini et al., 1986).

In the history of the sedimentary evolution of the Slovenian (or Friulan) basin, the sedimentation was influenced, during the Middle – Late Paleocene and Early Eocene by a particularly active syndepositional tectonism caused by orogenesis involving the innermost zones, in conjunction with an abrupt subsidence and with the collapse and break-up of a wide sector of the Friulan-Karstic platform. The beginning of the flyschoid sedimentation in the area in question is ascribed to this phase, at first with prevailing chaotic facies, megabeds, paraconglomerates and so on, then with predominant siliciclastic turbidites. Outside the area examined, these facies are well exposed, particularly in the Natisone valley ("Flysch di Canebola", Pirini et al., in press) and in the Idrija (Iudrio) valley ("turbidites and associated coarse facies", Tunis & Venturini, 1984). Near Anhovo (Kuščer et al., 1976; Buser & Pavšič, 1978; Skaberne, 1987) they are represented by a cyclic sequence containing megabeds and siliciclastic distal turbidites interbedded with calcareous proximal turbidites.

This was followed in the examined area in the Middle-Upper Cuisian by a phase of less intense orogenetic activity up to the Late Cuisian-Early Lutetian. According to the world-wide global eustatic model (Vail et al., 1977) during the Lutetian a transgressive phase began, but in the zone we have not clear elements of this event.

We should like to stress that, in the area examined, from north to south the outcrops progressively show a pronounced facies association change (a lateral facies variation is also evident inside the lower calcareous-marly-arenaceous facies) indicative of a wide variety of sedimentary environments. These range from relatively deep sea environments in the northern zone, where the oldest turbiditic sediments and the mainly coarse associated lithofacies were deposited, to transitional up to shallow water environments in the southern zone where the youngest sediments are clearly related to a fluvio-deltaic complex.

This area has been studied by several authors, mainly from the paleontological and pedological point of view (see Martinis, 1962, for the bibliography). Recent studies deal mainly with micropaleontology and biostratigraphy (Piccoli

& Proto Decima, 1969; Cimerman et al., 1974; Pavšič, 1977 and 1979; Cousin, 1981).

With regard to the exact chronological attribution of the Tertiary detrital formations of eastern Friuli and western Slovenia there is no complete agreement among the various authors (see, for example, Tab. XIII, p. 286, Cousin, 1981). It must therefore be presumed that the large number of depositional environments makes very difficult to define the exact biostratigraphic correlations on a regional scale.

Tab. 1 shows a comparison[1] of the various Paleogene detrital (and carbonatic) formations and units in eastern Friuli and western Slovenia.

Tunis and Venturini (1984) have studied the sedimentological characteristics of the thick flyschoid (and preflyschoid) Maastrichtian-Early Paleocene sequence in the upper Iudrio (Idrija) valley. The terrains of this valley above the "Flysch di Calla" (Early Paleocene) and especially those bounded by the "Megastrato di Mt. Ioanaz" (Early Ilerdian) and the "Megastrato di Vernasso" (Early Cuisian) are being studied at the time of writing, as are the younger Cuisian sediments which are also turbiditic.

The characteristic sequence of turbidites and megabeds in the Natisone valleys is also under study. This is being carried out in the Faedis-Attimis area, where the best outcrops are to be found.

In Cousin's subdivision (1981) the reason for his positioning of the base of the Medana beds is not clear. The author himself states: "la limite entre ces deux formations (Kožbana beds and Medana beds) est un peu arbitraire" (p. 277). The criteria by which he distinguishes the lower from the upper Medana beds are equally unclear. The reasons for his stratigraphic and chronological attribution of the younger deposits in the eastern Friuli hills are, in our view, even more tenuous. In the highest beds of the stratigraphic sequence of the Flysch di Cormons[2] we have never found any faunal associations more recent than Early Lutetian.

We gather from Pavšič (1979) that red marls with sandstone interbeds (Late Maastrichtian – Danian-Montian) are present in the vicinity of Lig, Colnica and Kanalski vrh. These beds are entirely similar to the coeval beds of the "Flysch di Calla", an important marker which may be followed from Breginj (Pavšič, 1985) along all the Natisone valleys as far as the Isonzo (Soča) river. Pavšič's account (profile Lig-Vrhovlje), however, does not make it clear where the Kožbana beds begin and what their relationship is to the underlying flysch.

The biostratigraphic study of these terrains is undoubtedly difficult, but the environments in sedimentary rocks can be defined not only by their faunal content, but also by their sedimentary structures, the geometry of their deposits and regional changes of thickness and facies.

A working team recently set up by researchers at the Ljubljana and Trieste Universities, with the aim of studying the flysch of the Goriška Brda and Vipava valley, indicated the following objectives as the most important ones: 1 – to give a more detailed description and more definite environmental interpretation of these beds; 2 – to provide a stratigraphy based on the correlation of the facies sequences within the depositional cycles, after a revision and a synthesis of the stages and members proposed by previous authors; 3 – to recognize the distribution of the sedimentary facies and to carry out paleogeographic reconstructions. Work on

[1] Our comparison takes account only of the most recent studies.

[2] The flysch di Cormons, which lies in the hilly area between Brazzano and Gorizia, was named by Martinis (1962), who distinguished the following facies in it: marly facies, marly-sandy facies, sandy facies and conglomeratic facies.

Tab. 1. Stratigraphic attribution of the paleogenic formations and units of eastern Friuli and western Slovenia

CARBONATE PLATFORM	AGE		CLASTIC DEVELOPMENT					
DROBNE, 1977; 1979 SW Slovenia and Istria			CIMERMAN, et al., 1974 Goriška Brda	ŠRIBAR, 1965 PAVŠIČ, 1977 Podsabotin	PAVŠIČ, 1979 Profils Kambreško-Lig; Lig-Vrhovlje	COUSIN, 1981 Eastern Friuli and Goriška Brda	PIRINI, et al., (in press) Natione Valleys	TUNIS & VENTURINI, 1985b Upper Iudrio Valley
	LUTETIAN	LATE				CORMONS, GORIZIA		
		MIDDLE				PLESSIVA, VENCO' KORADA (?)		
LIMESTONE WITH ALVEOLINAS AND NUMMULITES		EARLY				ROSAZZO AND NOAX, BUTTRIO AND MEDANA BEDS (upper part)	TURBIDITES AND MEGABEDS (FAEDIS, VALLE, PORZUS, FORAME)	
	CUISIAN	LATE	MEDANA BEDS					
		MIDDLE						
		EARLY				MEDANA BEDS (lower part)		
LIMESTONE WITH CHERT	ILERDIAN	LATE	KOŽBANA BEDS	PODSABOTIN BEDS (upper part)		KOŽBANA BEDS (upper part)	"Flysch di Canebola"	TURBIDITES AND ASSOCIATED COARSE FACIES (OBORZA, CODROMAZ, BERDA)
		MIDDLE						
		EARLY	KOŽBANA (PROFIL F)		KOŽBANA BEDS	KOŽBANA BEDS (lower part)		
LIMESTONE WITH MILIOLIDS	THANETIAN				GREYSH MARLS BRECCIAS (KOŽBANA BEDS ?)		"Flysch di Masarolis"	PREPOTISCHIS "Flysch di Masarolis" (SALAMANT, BORDON, CIUBIZ)
KOZINA LIMESTONE	MONTIAN				RED MARLS WITH SANDSTONE INTERBEDS (correspondig with "Flysch di Calla")		"Flysch di Calla"	"Flysch di Calla"
VREME BEDS	DANIAN			PODSABOTIN B (median part)				

objective[3] has begun on the Italian side of the border and a well-defined depositional suite has been recognized in the upper strata of the Flysch di Cormons (Late Cuisian – Early Lutetian).

The aim of this study is therefore sedimentological. It is one of the first attempts at a paleoenvironmental reconstruction of the area, essentially by means of the recognition and investigation of the sedimentary facies. We should state at the outset that we do not have a deep knowledge of the Kožbana beds and mostly of the Medana beds which mainly outcrop on Yugoslav territory, especially compared to the know-

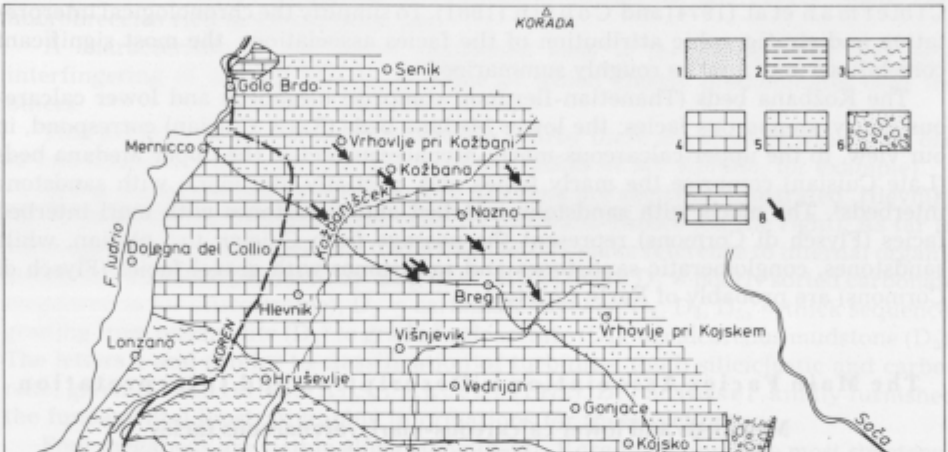


Fig. 1. Distribution map of the main facies associations

1. Podsabotin beds, *2.* Megabed of Plave, *3.* Megabeds and lower calcareous-marly-sandy facies, *4.* Upper calcareous-marly-sandy facies, *5.* Marly facies, *6.* Marls with sandstone interbeds and sandstones with marl interbeds facies, *7.* Sandstones, conglomeratic sandstones and sandstones with gravel facies. The arrows *8.* show directions of currents during the turbiditic sedimentation in the Kožbana zone ledge we have acquired about the Flysch di Cormons, where a bed by bed study of 400 small outcrops was carried out (Nardon, 1982).

From base to top of the stratigraphic sequence five facies associations were identified (Fig. 1), some of which include further subfacies: megabeds and lower calcareous-marly-arenaceous facies; upper calcareous-marly-arenaceous facies; marly facies; marls with sandstone interbed and sandstones with marl interbed facies; sandstones; conglomeratic sandstones and sandstones with gravel facies. The text contains comparisons between these associations of facies and the formations, facies, subdivisions and "zones" proposed by Comel[3] (1927), Martinis (1962), Cimerman et al. (1974) and Cousin (1981). To simplify the chronological interpretation and stratigraphic attribution of the facies associations, the most significant correlations may now be roughly summarized.

The Kožbana beds (Thanetian-Ilerdian) comprise megabeds and lower calcareous-marly-arenaceous facies; the lower Medana beds (Early Cuisian) correspond, in our view, to the upper calcareous-marly-arenaceous facies; the upper Medana beds (Late Cuisian) comprise the marly facies and, partially, the marls with sandstone interbeds[4]. The marls with sandstone interbed and sandstones with marl interbed facies (Flysch di Cormons) represent the passage from Cuisian to Lutetian, while sandstones, conglomeratic sandstones and sandstones with gravel facies (Flysch di Cormons) are probably of Early Lutetian.

The Main Facies Associations: Description and Interpretation

Megabeds and lower calcareous-marly-arenaceous facies

These facies correspond to marly conglomeratic formation (Cousin, 1981) and pelitic-sandy-conglomeratic flysch (Cousin, 1981), to the lower and upper part of the Kožbana flysch of Cimerman et al. (1974) and to the "transitional zone" of Comel (1927).

Near Plave (along the Plave-Šmartno road) there is a well exposed outcrop of megabreccia, characterized by undefined stratification and by marly matrix, which contains coarse to very coarse clasts of rudist limestone (hence the name of "conglomerato pseudocretaceo" given by Taramelli, 1870), pebbles of chert, outsize rip-up mudstone clasts (red and gray marls) and blocks of plastic formations i. e. turbidites up to 5 m in diameter. The fabrics of these sediments prove that they have been instantaneously remobilized from their original position. The thickest portion of this outcrop is given by thick bedded calcarenite, calcilutite and marl which directly overlie the breccia and represent the grading upwards. The megabed of Plave could correspond to the "Mt. Ioanaz Megabed" (Pirini et al., 1986). Above it, massive calciruditic-calcarenitic big beds are widespread, particularly on the southern flanks of the Mt. Korada (along the cartway Senik–Mt. Planina); they are characterized by the rareness of internal structures and slow grading upwards. In this part of the stratigraphic sequence sandstones with marl interbeds of turbiditic origin are fairly

[3] In his pioneer study Comel (1927) proposed the first division of the Goriška Brda into "zones". This study is entirely devoid of chronological attributions, but its lithological descriptions and pedological informations proved to be extremely useful, particularly in the study of the oldest terrains.

[4] We thus assume that the upper Medana beds correspond to the lower-middle part of the Flysch di Cormons.

common; they are represented by thin-medium layers. The complete T a-e Bouma sequence very rarely may be found.

Then, from west to east between Bucovizza, Mt. Brischis, Cladrecis, Stregna di Prepotto, Fragielis Mernicco, Restocina, Scriò (Italy), Vrhovlje pri Kožbani, Kožbana, Brdice, Brezovk, Slapnik, Nozno, Belo, Breg, Krasno, Vrhovlje pri Kojskem, Brestje, Vamorje (Yugoslavia) and probably S. Mauro and the upper Piumizza valley (Italy), several facies are present with rapid variations: megabeds, calcarenites, siliciclastic turbidites, sandy calcarenites, marls and marly limestones, paraconglomerates, fine breccias consisting of subangular calcareous and cherty clasts, rare microbreccias rich in nummulites, etc.

A characteristic of the above mentioned zone is the concurrence and local interfingering of several lithofacies, none of which clearly predominates over the others.

This peculiarity is more evident because nearby there are areas in which just one or two lithofacies predominate (the southern flanks of Mt. Korada, for example).

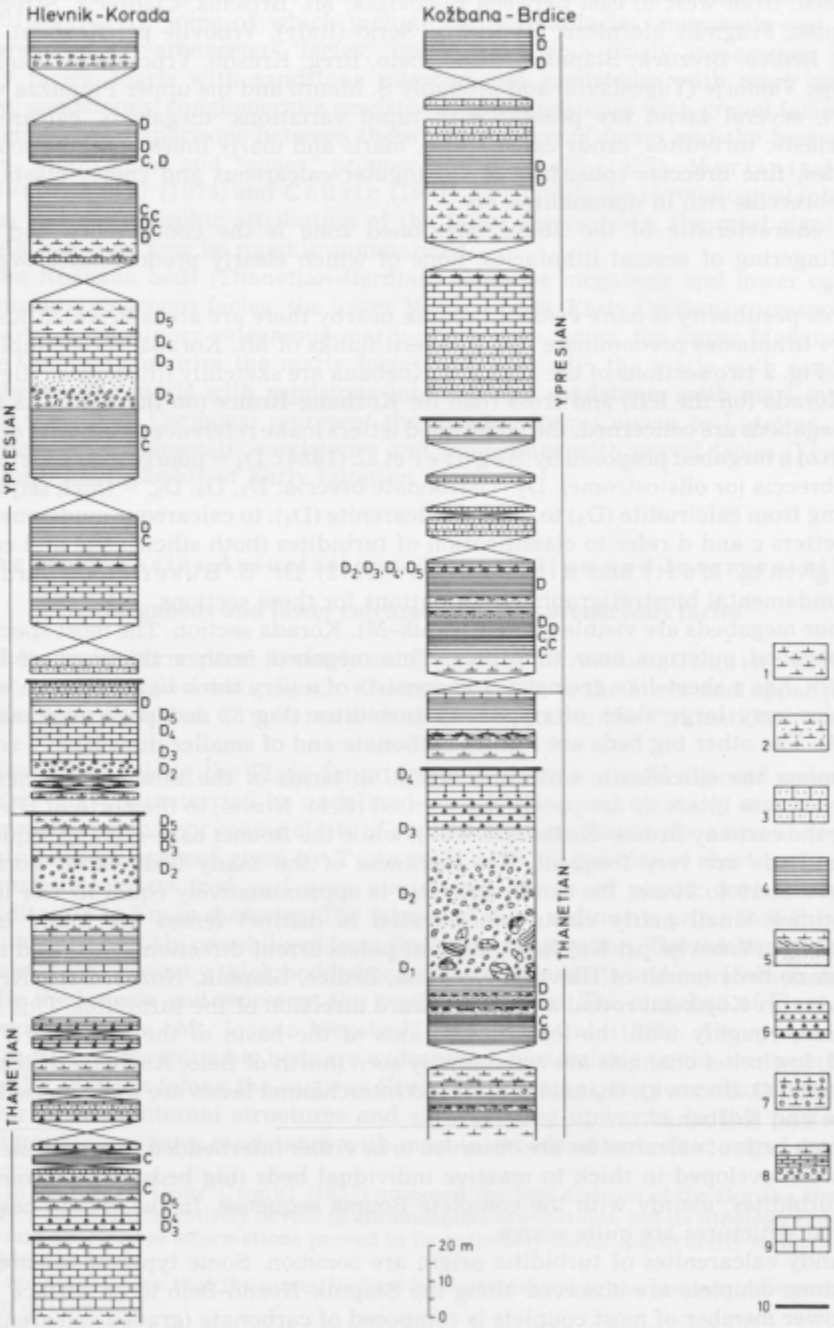
In Fig. 2 two sections of the Flysch of Kožbana are sketchily illustrated: Hlevnik-Mt. Korada (on the left) and cross road for Kožbana-Brdice (on the right). As far as the megabeds are concerned, the underlined letters make reference to internal organization of a megabed proposed by Seguret et al. (1984): D_1 = poorly sorted carbonate megabreccia (or olistostrome); D_2 = carbonate breccia; D_3, D_4, D_5, = thick sequence, grading from calcirudite (D_3) to graded calcarenite (D_4), to calcareous mudstone (D_5). The letters c and d refer to classification of turbidites (both siliciclastic and carbonate) given by Mutti and Ricci Lucchi (1972). Dr. S. Buser kindly furnished the fundamental biostratigraphic informations for these sections.

Four megabeds are visible along Hlevnik-Mt. Korada section. The most spectacular megabed outcrops near to Brdice. This megabed, with a thickness of up to 50–60 m, has a sheet-like geometry and consists of a very thick basal division which contains very large slabs of ripped up turbidites (Fig. 3) and paraconglomerates (Fig. 4). The other big beds are mainly carbonate and of smaller dimension.

Among the siliciclastic turbiditic layers, in terms of the Bouma sequence, the graded coarse intervals are poorly represented (Belo, Nozno, to the north of Hlevnik, along the cartway Brdice–Kožbanjšček R.), while the Bouma base-missing sequences bce and cde are very frequent. The thickness of the sandy beds varies normally between 5, 10 to 20 cm; the sand/marl ratio is approximatively equal to 1 or lower. Sometimes, small marly clasts concentrated in distinct lenses are found in the sandstones (Vrhovlje pri Kojskem). Several paleocurrent directions measured in the sandstone beds (north of Hlevnik, Kožbana, Brdice, Slapnik, Nozno, Belo, Krasno, Vrhovlje pri Kojskem) reveal a southeastward direction of the turbidites. This trend coincides roughly with the longitudinal axis of the basin of the Flysch of Friuli. Broad, low relief channels are occasionally seen (north of Belo, Kožbana, Kožbanjšček R. and G. Brezovk); channel (Fig. 5) and interchannel facies are well exposed near Brdice and Kožbana.

Thick beds of calcarenites are observed to be either interbedded to sandstones and marls or developed in thick to massive individual beds (big beds). The former are calciturbidites, mainly with the complete Bouma sequence. In the second case the internal structures are quite scarce.

Sandy calcarenites of turbiditic origin are common. Some types of calcarenite-sandstone couplets are observed along the Slapnik-Nozno-Belo loose surface road. The lower member of most couplets is composed of carbonate (graded calcarenite or


Hlevnik - Korada
Kožbana - Brdice
YPRESIAN
THANETIAN
D5
D4
D3
D2
D1
D2, D3, D4, D5
C, D
20 m
10
0
1
2
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4
5
6
7
8
9
10

coarse calcarenite), while the capping member consists of quartzose or lithic material. The relative thickness of carbonate and terrigenous members of such couplets is variable, but the sandstones invariably have a smaller thickness. There is often an abrupt junction between the two lithologies (Fig. 6).

The paraconglomerates consisting of subrounded clasts of limestone and sandstone up to 35 cm in diameter and smaller, well rounded chert pebbles are quite common. The fine nummulitic breccias (Belo) also contain limestone pebbles ranging from a few mm to 1–2 cm; these levels are highly cemented by calcareous cement unlike the nummulitic microbreccias interbedded in the marly facies (Vipolže and Russiz).

Discussion and interpretation

From the observed coarsest facies the depositional mechanism of these seems to have been caused by very rapid processes of resedimentation that occurred in a deep marine environment, but relatively close to the carbonate platform. At present it is rather difficult to define exactly the depositional environment (slope and/or basin's border) due to the lack of a detailed analysis and mapping of the different facies. We think, however, that the interpretation given by Pavlovec (1969) for the central Istria deposits could be acceptable also for most of these deposits. This author, on the basis of several paleoecological indicators and of the mixing of faunas of different ages and environments, hypothesized a relatively narrow and deep basin. One of the edges of the basin was an active slope connected to a carbonate platform; the slope was capable, because of the tectonics, of discharging huge masses of sediments. The slope on the other edge was either more gentle, or less tectonically active. We suppose that the more active side was situated near Banjšice (see also Cousin, 1981 and Skaberne, 1987).

Explanation as to the genesis of the megabeds is sought in the notable paleoseismicity of the area and in the high mobility of the basin. The outcrops of the Kožbana – Korada area are comparable in their affinities of characteristics to the Stregna Flysch Venzo & Brambati, 1969).[5] However, these outcrops of chaotic facies are generally less wide, less thick and less frequent compared to the coeval ones in the area situated near Stregna, Canalutto, Clap or Canebola.

A last problem rises from the examination of the Paleocene facies outcropping near Mt. Sabotin, between Podsenica and Podsabotin, and in Piumizza valley where marly calcareous lithotypes predominate and near Groppai and S. Mauro where thin sandstones with marly interbeds (turbidites?) prevail. This is interpreted as lateral facies change. The relationship between the turbiditic facies and big beds to the west and these last facies, which may be observed in the easternmost area, is not clear.

[5] We would like to point out that the term "Flysch di Stregna", whose biostratigraphic description was unsatisfactory, is currently being abandoned.

Fig. 2. Columnar section of the sequence with turbidites and megabeds outcropping along Hlevnik–Mt. Korada road and cross road for Kožbana–Brdice

1. Marls and marly limestones, *2.* Calcisiltites, *3.* Sandy calcarenites (turbidites), *4.* Siliciclastic turbidites (classification according to Mutti & Ricci Lucchi, 1972), *5.* Calciturbidites, *6.* Fine breccias consisting of calcareous and cherty clasts, *7.* Paraconglomerates, *8.* Megabeds (internal organization according to Seguret et. al., 1984), *9.* Carbonate big beds, *10.* Faults

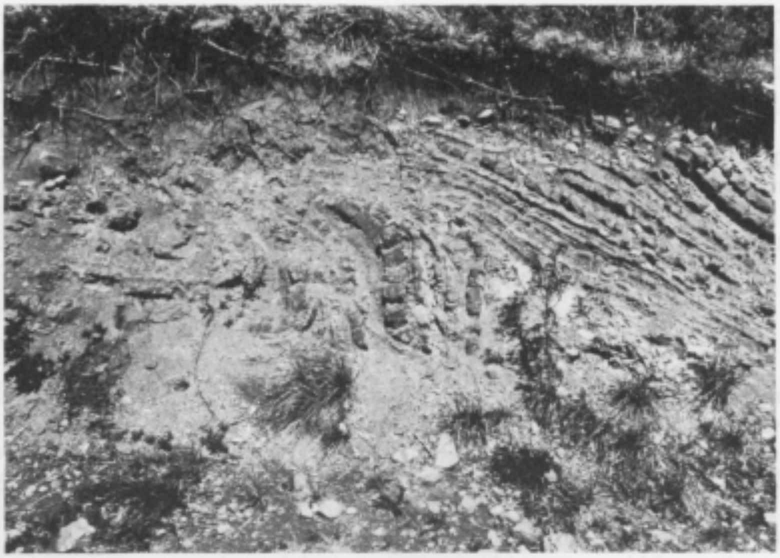


Fig. 3. Well exposed basal unit of Brdice megabed (Flysch of Kožbana) mainly consisting of large deformed rip up layers of turbidites

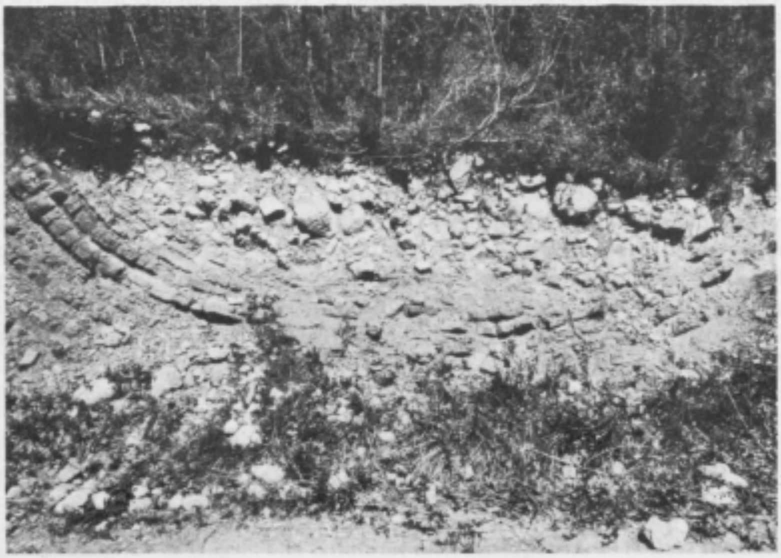


Fig. 4. Channel-like body composed of matrix supported conglomerate within the basal unit of the Brdice Megabed (Flysch of Kožbana). The light colored limestone blocks and cobbles are predominantly platform limestones

Fig. 5. Channelized sandy body in the Flysch of Kožbana (Kožbana village)

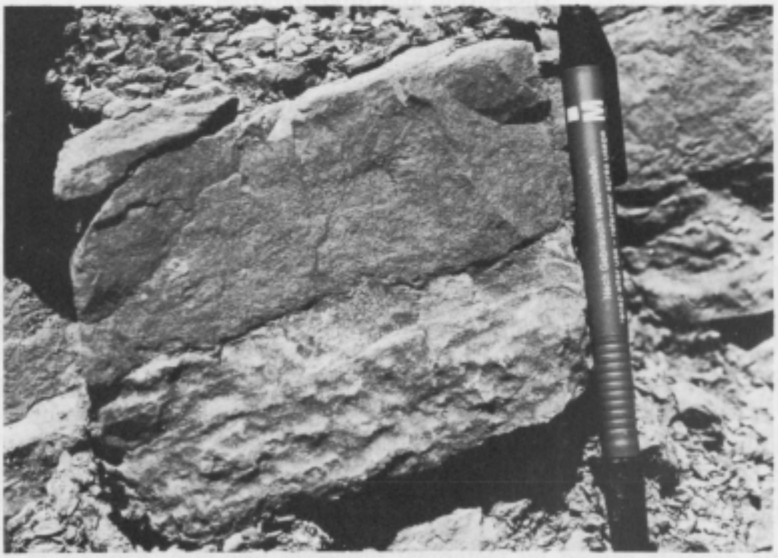


Fig. 6. Photograph of a limestone – lithic sandstone couplet from Kožbanjšček–Brdice cartway (Flysch of Kožbana). The limestone rests on an eroded surface of marl. Note irregular base and poor grading of the sandstone unit

The development and distribution of the eastern facies have probably been conditioned by paleomorphology and by syndepositional and postdepositional tectonics.

Upper calcareous-marly-arenaceous facies

These facies, described by Tunis (1976), could correspond to the lower marly-arenaceous facies and the middle marly-arenaceous facies p. p. of Comel (1927), and to the lower and middle parts of the Medana Flysch of Cimerman et al. (1974).

Calcarenites, calcilutites, sandstones with marl interbeds and marls outcrop along a belt extending from Pojanis, south of Scriò, Dolegna, Lonzano (Italy) up to Kojsko and the S. Floriano area through Hlevnik, Hruševlje, Pristava, Slavče, Višnjevik, Vedrijan, Imenje, Šmartno and Gonjače. Calcarenites and calcilutites are mainly present in the lower part of the sequence associated with marly-arenaceous interbeddings of turbiditic origin and marls (having marked lateral continuity), and with very rare individual beds of fine breccia.

The marl sandstone interbeddings in comparison with those of the lower calcareous-marly-arenaceous facies, are thinner, finer and less rich in internal structures and sole marks.

Going up the stratigraphic sequence (south of Lonzano, Vencò, Ruttars, Neblo, etc.), thin bedded sandstones and marls are still present with a sand/marl ratio generally lower than 1, while the calcarenitic beds become gradually rarer and less thick and the calcilutites and marls progressively predominate.

Discussion and interpretation

This facies association could be considered as belonging to the lower calcareous-marly-arenaceous facies and to the superimposed marly facies, and objectively, at our current level of knowledge, it would be difficult to define its exact stratigraphic limits. Nevertheless, all these facies or subfacies – they can probably be defined and mapped one by one – are discussed here because they have several common distinctive features. First of all they are Lower-Middle Cuisian in age and contain Paleogene faunas only, while the lower facies (lower calcareous-marly-arenaceous facies) are characterized by a mixing of Cretaceous and Paleocene faunas (Cimerman et al., 1974). A rarefaction, from gradual to abrupt, of conglomeratic and calcarenitic beds was noted, as already observed by Comel (1927) and Cousin (1981). To these peculiarities must be added a progressive rareness of the turbidites, which disappear near to Lonzano.

In the above mentioned area important tectonical disturbances are visible. There is a lot of evidence of these: the beds appear verticalized, suddendly folded, sometimes disrupted and often broken along a line from Pojanis Hill (Italy) to Kojsko, through Mounts Candia and Komnina, the Gradno Hills, Višnjevik and Vedrijan (see also Carobene, 1984). South of this alignment, the sporadic appearance of turbiditic layers, in the light of the above, could represent also the result of displacements of turbiditic deposits caused by tectonical processes (see also Amato et al., 1976; Placer, 1981: Fig. 7). To the south of the faulted and "overthrusted" zone, the prevalence of marls point to a quiet marine environment; most of the facies here would have originated from a slow fall-out of fine material. The presence of 50 to 150 cm thick fine grained sandstone beds in the upper part of the sequence seems to be linked mostly with physical factors (storm waves and/or currents) rather then with paleotectonics (faint pulsations inside the basin) whose characteristics are lacking.

Marly facies

This facies was described by Martinis (1962) as a part of the Flysch of Cormons. It corresponds to the upper part of the Medana Flysch of Cimerman et al., 1974 (see also Buser 1968 and 1973; Drobne, 1979). The marls represent one of the most widespread lithotypes in the examined area. They outcrop in the area around Ruttars, Brazzano, at the foot of Mt. Quarin, on the Croce Hills, between Spessa and Russiz di sopra, at Blanchis, Giasbana, from Gradiscutta to Oslavia in Italy and at Barbana, Fojana, Dobrovo, Biljana, Medana, Vipolže, G. Cerovo in Yugoslavia. This facies is represented by thick beds of marly limestones and silty marls which are compact, vertically monotonous and structureless. When washed, these marls leave a residue of quartz grains and, to a lesser extent, mica flakes, small well rounded chert grains, limonitic concretions, pyrite crystals and scarce elements of light limestone.

In the middle part of the stratigraphic sequence of the marly facies, fine calcareous subgraywackes appear in layers up to 1 metre thick, vertically graded, extensively rippled and wavy, with plane parallel and low angle lamination and with sharp contacts both at the base and at the top (hummocky layers).

Very thin layers of fine sandstone are interbedded in the marls; they are frequent, although not ubiquitous.

It is common to find (Case Limband, Russiz, Subida, D. Cerovo, Vipolže) 10 to 25 cm thick layers of microbreccia with interstitial marly-calcareous cement, composed mainly of macroforaminifera and subordinately by well rounded cherty and calcareous clasts. Often in such layers Nummulites and Assilinae are found in bands parallel to the stratification.

Inside the marly facies, carbonate breccia (or a calcareous belt) with alveolinas, nummulites, assilinas and discocyclinas are occasionally found (south of Ruttars, Tunis, 1976; east of Vipolže, Cimerman et al., 1974).

Layers of pebbly marls are frequent at the top of the marly facies. They are mainly composed of chert pebbles ranging from 3–4 mm to, exceptionally, 30 cm, quite well sorted and well rounded.

At the very top of this sequence there are pebbly mudstone outcrops with a rich, macro and micro invertebrate fauna. The fossils are in various states of preservation, molluscan shells are often abraded. The fauna has some affinities with tropical faunas and consists of several species; corals both colonial (of large size) and isolated, gastropods, bivalves and very abundant macroforaminifera. These deposits, because of the abundance of macrofaunas and of chert pebbles and due to their areal extent, could be considered as a subfacies, called here "fossiliferous pebbly marls".

The assemblages of the microfossils found in this marly facies are not very rich in species and in specimens. Among the planktonic foraminifera, *Globorotalia (Acarinina) crassata densa* is present throughout the section; the globigerinae are always of small size. Among the benthic foraminifera Nodosarinidae, Buliminidae and Anomnalinidae are constantly present. The Bosco di Corrado fossiliferous outcrop, rich in *Nummulites (N. friulanus, N. quasilaevigatus)* and *Assilinae (A.* ex gr. *spira* and *A.* ex gr. *exponens)*, is of particular interest.

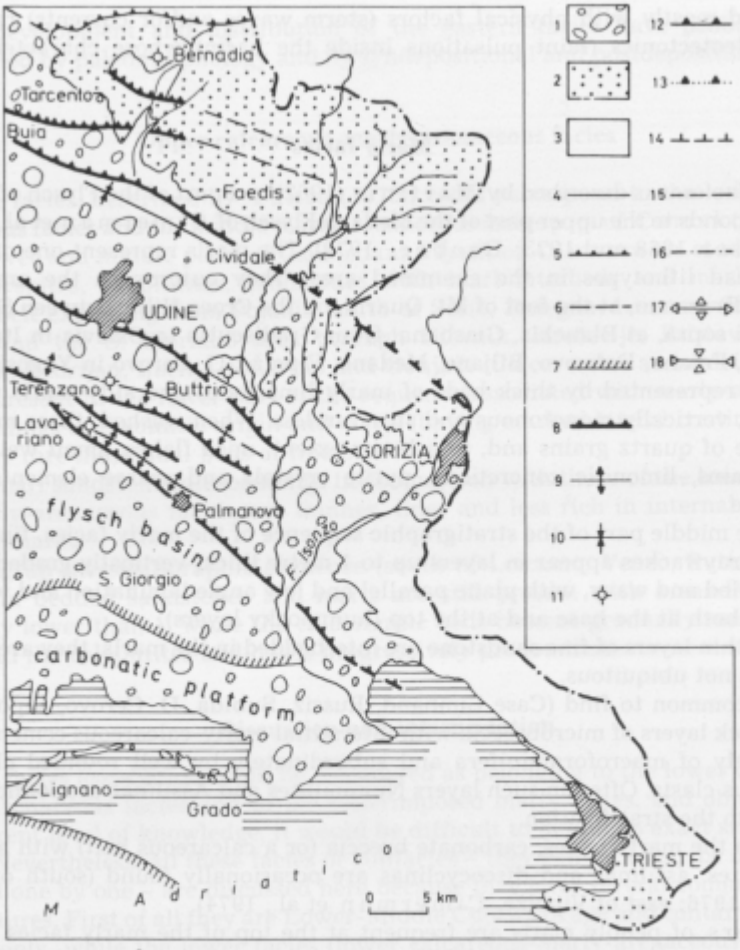
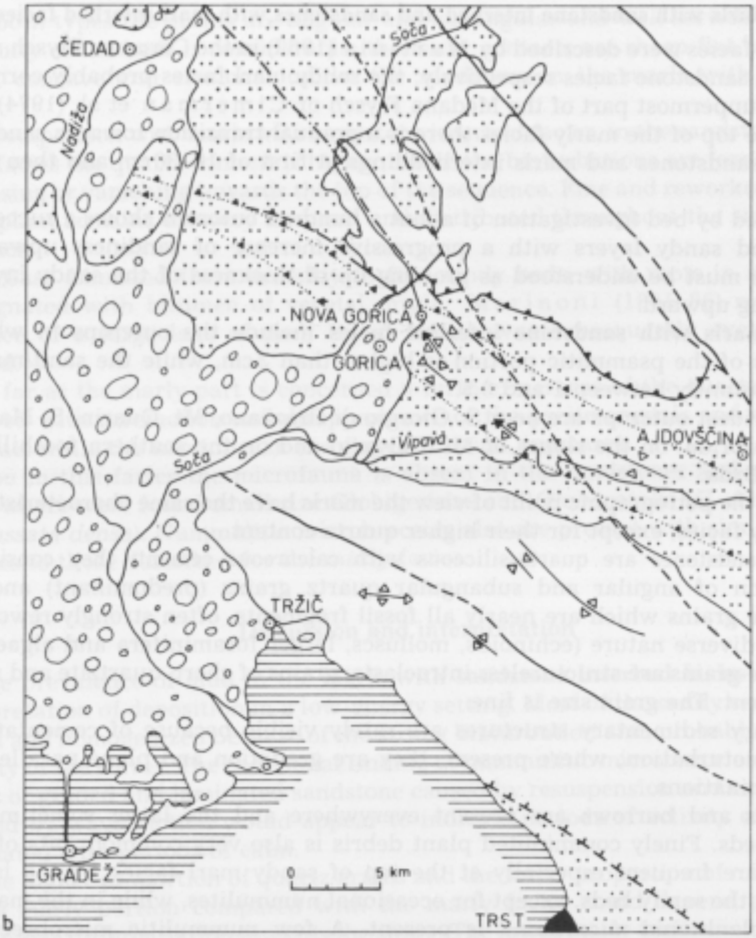


Fig. 7. Tectonic map of southeastern Friuli (a- Amato et al., 1976) and of southwestern Slovenia (b- Placer, 1981)

1. Quaternary deposits, *2.* Eocene – Paleocene – Late Cretaceous flysch, *3.* Tertiary and Mesozoic rocks, *4.* Geological boundary, *5.* Overthrust and reverse fault, *6.* Main fault, *7.* Boundary of uplifted platform, *8.* Boundary of nappe and thrust sheet, *9.* Anticlinal axis, *10.* Synclinal axis, *11.* Well, *12.* Boundary of nappe and thrust sheet, *13.* Assumed thrust plane, *14.* Reverse fault, *15.* Fault concealed, *16.* Fault identified by means of photogeology, *17.* Brachyanticline, *18.* Brachysyncline

Discussion and interpretation

On the whole, the sediments seem to have been deposited slowly from a suspension of fine material, in a quiet marine environment, mostly below the normal wave base level. The presence of hummocky layers at about the middle of the stratigraphic sequence suggests that occasionally the seafloor was agitated. The scale of the structures, from medium to large, could relate them to storm waves.



The thin interbeddings of fine sandstones, structureless and bioturbated, can be attributed to a wave-induced bottom sediment surge.

The presence of nummulitic microbreccias with generally well preserved specimens is attributed to the reworking, over short distances, of nummulitic bars prosperous at reduced bathymetries near the shoreline.

The frequent coarse size and the general high sphericity of the pebbles in the pebbly marls suggest their previous reworking (fluvial or marine) and certainly their transport by wave motion along a shoreline. Plint (1983) explains a similar facies as a result of an offshore migration of a pebble beach. As the geometry of this pebbly body is tabular on the whole and considering the presence of the marl, it seems plausible to consider instead a mass gravity transport mechanism, such as debris flow. The large amount of marl would also have favoured the preservation of the macrofaunas involved in the mass flow.

Finally, an interesting tectonical problem, now under study, is posed by the presence of outcrops of breccias with alveolinas and nummulites.

Marls with sandstone interbed and sandstones with marl interbed facies

These facies were described by Martinis (1962) in the Cormons Flysch as sandy marl and sandstone facies respectively; the sandy marl facies probably corresponds with the uppermost part of the Medana Flysch of Cimerman et al. (1974).

On the top of the marly facies there is a gradual transition towards sandy facies through sandstones and marls interbeddings at first of 10–30 cm and then of 30 to 100 cm.

The bed by bed investigation of about a hundred outcrops shows a succession of marly and sandy layers with a progressive increase of sandiness upward. The sandiness must be understood as growing up of thickness of the sandy layers and coarsening upward.

The marls with sandstone interbed facies include the outcrops in which the thickness of the psammitic portion is higher than 3 cm, while the sand/marl ratio ranges costantly between 1 and 0,5.

The widest outcrops are near S. Giorgio di Brazzano, Mt. Quarin, S. Mauro, Mt. Galuz, Pubrida, on the slopes of Mt. Calvario and on the southern foothills of the Goriška Brda.

From the petrographic point of view the marls have the same characteristics as in the marly facies, except for their higher quartz content.

The sandstones are quartz-siliceous with calcareous cement; they consist of an association of angular and subangular quartz grains (predominant) and minor carbonate grains which are nearly all fossil fragments, often strongly reworked, of a highly diverse nature (echinoids, molluscs, larger foraminifera and algae). Other carbonate grains are structureless intraclasts; grains of chert, quartzite and mica are also present. The grain size is fine.

Primary sedimentary structures are rarely visible because of cementation and intense bioturbation; where present, they are gradation and plane parallel or low angle laminations.

Tracks and burrows are present everywhere and the latter sometimes cross several beds. Finely comminuted plant debris is also very common; bits of vegetal detritus are frequent especially at the top of sandy marl facies. Fauna is almost absent in the sandy beds, except for occasional nummulites, while in the marly beds a poor planktonic microfauna is present. A few nummulitic microbreccias are interbedded with the marls.

The sandstones with marl interbed facies is also a monotonous alternation of sandstones and marls. Thin layers (10–30 cm) prevail in the lower part, while in the upper part the thickness increases to 30–100 cm. The sand/marl ratio is always higher than 1, generally it is around 2, occasionally 4.

Sandstones with marl interbed facies is frequent in the area of S. Giorgio, Mt. Quarin, Croce Alta, Budignacco, Bienich, Valleris, Mt. Calvario and Forte nel Bosco. Grain size is fine to medium fine, coarse at the top where the sandstones are scarcely cemented and immature from the textural point of view.

Two types of sandstone are generally present. The prevailing type has fine grain size with infrequent sedimentary structures as plane laminations, both horizontal and gently inclined, and a few very small scale ripples. The rock is bioturbated and rich in comminuted plant debris.

The second type has medium fine grain size; it is structureless and scarcely bioturbated. At a few levels it has an erosive base and contains small cherty clasts, clay chips and reworked nummulites.

In both types the grains are angular and subangular and well sorted, the lateral continuity of the beds is considerable, the lower contacts are sharp flat but, occasionally, concave and erosional unlike the sandstone in the marls with sandstone facies.

In comparison with marls with sandstone interbed facies, in the sandstones of this latter facies the quartz content is higher, while the bioturbations are less strong and decreasing or vanishing towards the top of the sequence. Fine and reworked carbonaceous plant remains are very frequent and distributed throughout the stratigraphic sequence.

At Case Limband there are silty to fine sandy beds, with roots in some cases, impregnated with bitumen of vegetal origin. Marinoni (1881–86) reported the presence of a large lens of dark lignite which was subsequently excavated and utilized.

As far as the marly part is concerned a further increase of the quartz content is observed with rarefaction and disappearance of the pyrite crystals and of the mica lamellae, while the kaolinite, in the clayey fraction, increases.

Also in this facies the microfauna is absent in the sandstones and poor in the marls where were found small size Globigerinae and *Globorotalia (G. Acarinina)* ex gr. *crassata densa*). Nummulitic microbreccias also are present with similar characteristics to those described for the marly facies.

Discussion and interpretation

The prevalence of mud in the **marls with sandstone interbed facies** leads to an interpretation of deposition in a low-energy setting. Most of the sandy sediments are mixed and homogenized because of the strong bioturbation and, probably, due to the activity of the waves. The occasional finding of nummulitic microbreccias and of thin layers of graded and laminated sandstone caused by resuspension and concentration of sand by wave motion would appear to indicate periods of activity of the waves alternated with periods of calm.

The higher proportion of quartz grains and the lower proportion of mica lamellae in the marly portion compared with the marly facies could depend partially on a grain size differentiation towards the shore. The lower marly facies would therefore represent a depositional environment »further offshore« and deeper in comparison with marls with sandstone interbed facies.

The increase of the quartz percentage in the sandstone beds suggests a mixed petrographical assemblage progressively changing towards the top of the stratigraphic sequence. In fact the limestone components of shallow marine origin are in gradual decrease upward and the allochthonous terrigenous components increase proportionally. The bioturbation would exclude high rates of sedimentation even though the observation of vertical systems of burrows crossing several beds shows the presence of organisms adapted to survive in environments subject to quick sedimentation and erosion, and therefore on an unstable substrate (Seilacher, 1967). This facies could be traced to a prodelta environment or to a deltaic front (see Homewood & Allen, 1981), but, in any case, to a relatively nearshore environment with shallow bathymetry and connected to a delta system. The thin tabular sand bodies would represent the fringes of a delta front. The idea of a shoreface may be ruled out because of the rareness of high energy indicators such as primary sedimentary structures, fossil tracks and grain size characteristics.

As far as the **sandstones with marl interbed facies** is concerned, the laminated sandstones at the base still show evidence of wave motion. The intercalations of marls and sandstones organized in thickening and coarsening upward sequences are indicative of proximality conditions accompanied obviously by reduced bathymetry caused by deltaic aggradation. It is not easy to define carefully the specific depositional environments. The global sedimentological characteristics could denote a progressive paleoenvironmental evolution from a submarine deltaic front up to a deltaic plain or at least to a "transition zone" (sensu Wescott & Ethridge, 1983). In these types of environments the delicate balance of sedimentation, subsidence and sea level changes can give rise to an extremely differentiated scenery which is more or less stable in the time (Ricci Lucchi et al., 1981). The thickest sandstone beds are seldom bioturbated, and it should be pointed out in a speculative way that this may reflect either a continuous physical reworking of the sediments, which the scarcity of current marks makes improbable, or unfavourable biotic conditions (Eh, pH, or salinity), or, more probably, higher rates of sedimentation. In this area a coastal shifting could have taken place as it is indicated by the sandstone beds with erosional base, clay chips and small pebbles, and by the prograding of sand bodies sedimentologically characterized by slight coarsening upward, i. e. mouth bars, lagoonal barriers, etc.

Lastly, in the upper beds the association with lignites suggests a deposition in shallow water or in semiemergent conditions (lakes, marshes and ponds of coastal plain). Generally, lignites all deposit in restricted nearshore brackish basins (Plint, 1983) where material can accumulate while a dense vegetation develops.

Sandstones, conglomeratic sandstones and sandstones with gravel facies

The **sandy facies** and the **conglomeratic sandstone facies** are extremely limited (Prati Grandi, Mt. Calvario, Mt. Quarin, hill 242 of Mt. Quarin).

The former **(sandy facies)** consists of medium to coarse sandstone beds up to 120 cm thick, with a high sand/mud ratio. The sandstones are generally structureless, except for the normal graded bedding. Near to Gorizia and Nova Gorica, sequences of strata of the sandy facies show pinch outs; the most frequent structures are gradation, cross planar stratification and perhaps festoons.

The latter **(conglomeratic and microconglomeratic sandstones facies)** consists of subangular to subrounded cherty and calcareous clasts, from 2 to 10 mm. The thickness of the beds is around 30–50 cm, the hardness is variable in relation to the different proportions of sandy matrix and of calcareous cement. Gradation, crude lamination and minor pebble imbrication are occasionally seen in the conglomeratic sandstones. Thin levels of pebbles of larger size, nummulites and, exceptionally, reworked and broken macrofossils are confined to the bottom of some beds (coquinoid graded beds are present near Case Peressin).

In both facies the base of the beds is flat or concave.

The **gravelly sandy facies** outcrops in the Bosco di Plessiva, Mt. Quarin, at altitude 240, Subida, the Croce hills, between Valleris and Uclanzi, Rožna dolina and Okroglica (Pavlovec, 1963). It consists of gravel and pebble beds, mostly matrix supported (with pelitic – sandy matrix) and subordinately clast supported. In this last case the poor sorting and the random distribution of the clasts give a misleading appearance of a matrix supported conglomerate. These conglomerates are disorganized and not stratified. The clasts, generally well rounded, have size ranging from 0,5 to 3–4 cm up to a maximum of 20 cm. They are of various origins: chert (largely predominating), several calcareous lithotypes (Volče limestone), marly limestones and sandstones. It is not possibile to make accurate observations about the geometry of the beds, but it is our impression that the tabular unchannelized deposits prevail.

Discussion and interpretation

The depositional history of these sediments denotes increasing fluviatile influence and indicates an interaction of marine and fluvial processes, initially with the prevalence of the former. We are not yet in possession of sufficient data to suggest any other hypotheses about the **sandy** and **conglomeratic sandstones** facies. Clifton (1973) interpreted similar conglomeratic sandstones and fossiliferous sandstones with horizontal stratification as shoreface and foreshore deposits. In the area examined, the conglomeratic sandstones are segregated from the sandstones in which they are interbedded; lateral transitions between the two lithotypes were never observed. These characteristics, according to Clifton, indicate a "wave worked gravels as opposed to fluvial gravels which are lenticular and not well segregated into discrete laminae".

The presence of disorganized conglomerate **(gravelly – sandy facies)** with abundant pelitic matrix may be related to transport mechanisms of debris flow even though they are not characterized by a high flow competence. The unusually high sphericity of the cherty clasts suggests their strong fluvial reworking. The probable tabular shape of the gravel beds would also suggest reworking caused by wave motion, albeit quite moderate. The chert is derived from limestones with chert nodules and sheets of Malm, Early Cretaceous and Late Cretaceous (Soča Valley). This facies, on the basis of the existing models, could be referred to as a "non channelized deltaic plain environment" (Ricci Lucchi et al., 1981).

Paleogeographic Evolution

In accordance with what has already been said, it is possible to infer that the clastic deposits of the Goriška Brda represent a wide range of environments that successively embrace: (i) relatively deep sea conditions of lower slope and/or border of basin (megabeds and lower calcareous-marly-arenaceous facies and upper calcareous-marly-arenaceous facies p. p.), (ii) mixed siliciclastic and carbonate external and internal platform (upper calcareous-marly-arenaceus facies p. p. and marly facies), (iii) deltaic front (marls with sandstone interbed facies, sandstones with marl interbed facies) and (iv) deltaic plain (sandstones, conglomeratic sandstones and sandstones with gravel facies).

Regarding the deep sea facies we suppose (see also Pirini et al., 1986) that there was a "ridge" originated by tectonical structures already existing at the time of the sedimentation of the Flysch of Kožbana. This morphostructural element was placed transversally and partially laterally with respect to the NW-SE basin axis of the Friuli flysch and separated the turbiditic deposits (Kožbana beds) from the non visible deposits of a carbonate platform subsequently covered by terrigenous sediments (upper Medana beds and Flysch of Cormons). We think that this could explain the turbiditic facies zonation in Friuli and Goriška Brda with the decrease of the coarsest lithofacies from NW to SE, the difficulties of wide scale correlations of the megabeds and some lateral facies association changes in the Goriška Brda region.[6]

[6] The lateral facies variation, from turbidites and megabeds in the west to thin marl with sandstone interbeddings in the east, in the lower calcareous-marly-arenaceous facies stated previously.

Inside the upper calcareous-marly-arenaceous facies the deposits show important tectonical disturbances. Here (between Pojanis and Kojsko) there are overthrusts and faults (Amato et al., 1976; Placer, 1981) which also display the NW-SE direction. With reference to the overthrusts of southwestern Slovenia, Placer (1981) gives the distances and displacement directions of the main structural units (the Trnovo nappe, for example, which affects also the Goriška Brda, was driven for 29 km in the area of Trnovo forest).[7] We are not able to express an opinion on this remarkable thrust length but we would stress the importance of the fact that above the Thanetian Kožbana megabeds there is no sign of the thick Cuisian sequence (over 1000 m thick) with turbidites and megabeds found in Friuli in the whole sector north of the line Faedis-Cividale.

The supposed presence of the overthrusts, together with the fact that the greatest shortening in the entire area took place between Mt. Sabotino and Gorizia, makes it very difficult to locate the position of the ridge (which we have postulated) and complicates all the problems connected with the turbiditic and non-turbiditic deposits.

At present we only have fragmentary knowledge concerning the zone of transition between the northern area, where the older deposits (turbidites and megabeds) are to be found, and the southern area where a "relatively" shallow water clastic terrigenous regime was established during the Early Eocene.

To return to the paleogeographic evolution, the deposition of the Flysch of Medana (upper part) and of the Flysch of Cormons (lower part) was affected by subsidence, which probably had its origin in the load which caused a general uplift of the northern areas, the main source region of the siliciclastic materials. The uplift gave rise to a sedimentary cycle from the Late Cuisian to the Early Lutetian (mainly regressive) which is well documented, mostly by the study of the marls with sandstone interbed facies and sandstones with marl interbed facies.

Before and during the regressive phase, small transgression-regression fluctuations, due to oscillatory basin subsidence, are probably present (marly facies). The fossiliferous pebbly marl subfacies (inside the marly facies), in fact, records a marine transgression. As the shoreface equivalent of the marly facies (which instead belongs to the external platform) has not been found, we would postulate an offshore shift of a pebbly beach: the waves reworked near the coast fluvial deposits from an alluvial delta, building up pebble-sand mixed beaches. A probable pre-indication on this shifting is given by very thin monotonous rhythmic intercalations of sandstones and marls in the marly facies. These last ones could represent either lower shoreface deposits (Bourgeois, 1980) or prodelta deposits (Sarntheim & Walger, 1973, Cason et al., 1980, Ricci Lucchi et al., 1981).

The marls with sandstone interbed facies is also indicative of a calm water environment, interrupted by phases of weak wave winnowing. The seabottom on the whole does not seem to have been strongly agitated even when the bathymetry is very low; this could be connected to waves of extremely limited fetch.[8]

The monotonous sequence of thin sandstone and marl beds, in shallow sea conditions, indicates a phase of steady equilibrium between subsidence and deposition.

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[7] There is not a great deal of field evidence (in the southern Goriška Brda) of the second, more southern, thrust plane proposed by Placer. In the Ruttars area there is, however, an important disturbance; in Cà delle Vallade there is an other fault (probably inverse).

[8] The only exception is represented by the ripple and wavy laminated calcareous subgraywackes, ascribed to storm waves, found approximately in the middle of the marly facies sequence.

Afterwards, with the sandstones with marl interbed facies, sedimentation overcomes the effect of subsidence, causing a decrease in the bathymetry almost to the point of emersion. The moderate action of synsedimentary tectonics during the building up of the delta front (that corresponds with the sandy-marl and marly-sandstone facies deposition) allows us to attribute little importance to this factor in our estimation of the sedimentation rate. Considering a thickness of 500 m and a time interval that could range from 2 to 4 MY a value of 10–20 cm/1000 yr is obtained; this could indicate a moderate or not too high amount of material input. Even if a regressive phase is generally not very preservative, breaks in the sedimentation have not yet been observed.

There are no substantial differences between the microfaunas of the examined sequences and they do not therefore offer clear elements with which to define the association zones.

On the one hand this suggests the hypothesis that the building of the delta happened in a relatively short period, and on the other hand would confirm an assumption of Wescott and Ethridge (1980), but with regard to fan deltas. According to these authors, the biostratigraphic criteria are inadequate for the differentiation of the fan delta paleoenvironments.

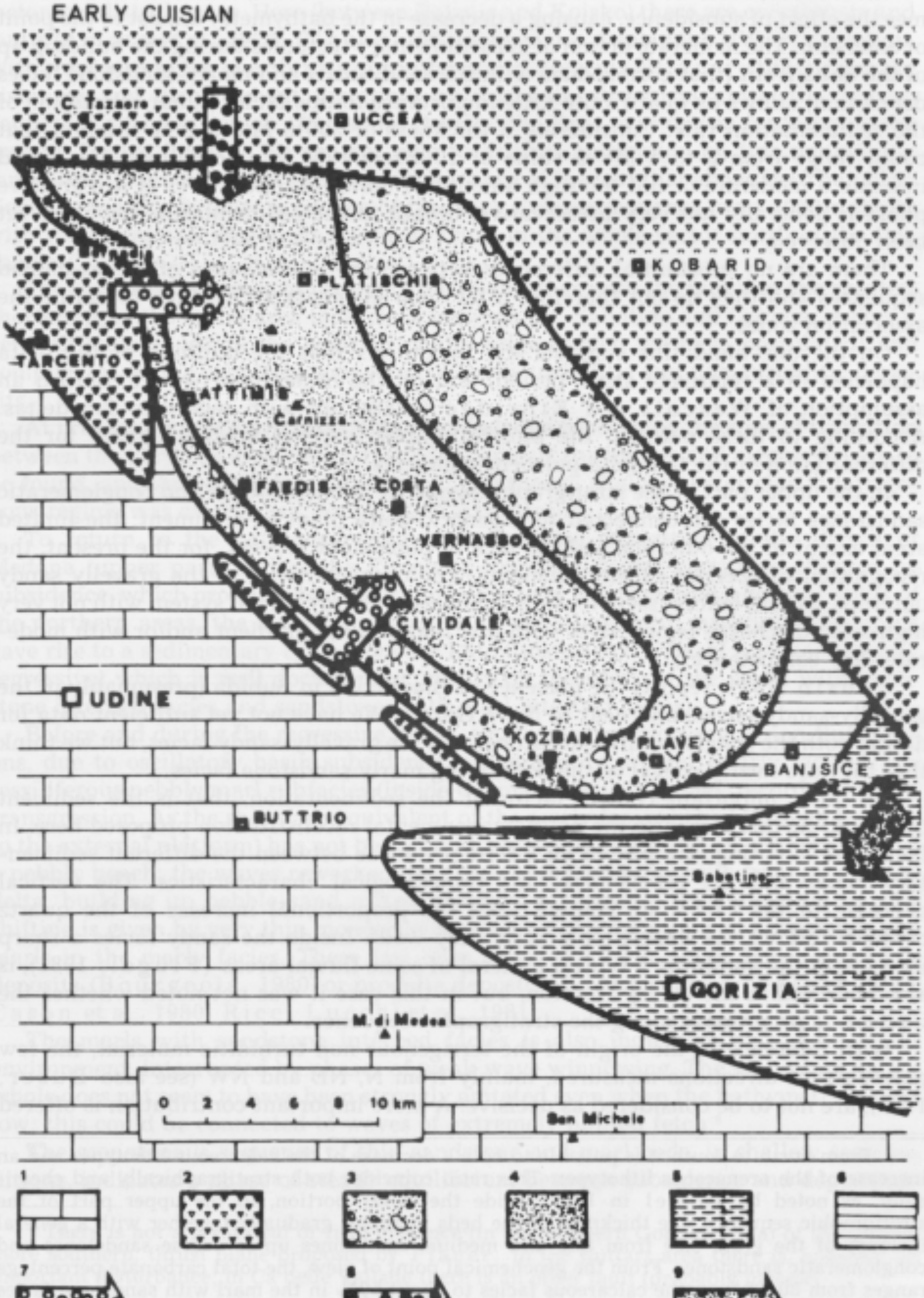
In the upper part of the stratigraphic sequence the sandstones and conglomeratic sandstones facies are connected to a generic delta plain environment; the limited areal extent of the outcrops and the lack of other data prevent, for the present, the recognition of specific subenvironments. The characteristics of the gravelly sandy outcrops, as said before, seem to show a moderate energy fluvial system with not very high solid discharge (small river with low longitudinal gradient and/or with moderate flow competence?).

Cousin (1981) reports the presence of Biarritzian in Subida (presumably in the gravelly-sandy facies) and near to Nova Gorica. We have not yet sufficient data for dating both the conglomeratic sandstones and the gravelly-sandy facies, but we think that they are nearly coeval to the underlying marly sandstone facies.

An other important control factor of the sedimentation, that is the sediment dispersal, further supports the paleoenvironmental reconstruction proposed here. In fact there is strong evidence of an interdependence between the different sedimentary facies and the geochemical and mineralogical characteristics. The vertical decrease in the carbonate content (and the proportional increase of the quartz content) follows the depositional suite very well[9]. Inside the sandy facies a sharp increase of the kaolinite, a typical mineral of some fluvial areas (Flügel, 1981), is also observed in the clayey fraction, but in this case it was not noted whether the increase is progressive along the stratigraphic sequence.

With reference to the origin of the terrigenous non turbiditic material, the few paleocurrent directions measured, mainly from N, NE and NW (see also Buser, 1973), are not to be considered as decisive. A more important contribution is offered

[9] From north to south it is possible to note a decrease of the calcareous lithotypes and an increase of the arenaceous lithotypes. This ratio coincides both stratigraphically and chemically, as noted by Comel in 1927. Inside the sandy portion, in the upper part of the stratigraphic sequence, the thickness of the beds increases gradually together with a general increase of the grain size from fine and medium sandstones up to coarse sandstones and conglomeratic sandstones. From the geochemical point of view, the total carbonate percentage ranges from 80–90 % in the calcareous facies to about 50 % in the marl with sandstone facies and to 10 % in the coarse sandstones collected near Subida (0.5 in a sample of conglomeratic sandstone).


EARLY CUISIAN
C. Tazaro
UCCEA
KOBARID
PLATISCHIS
TARCENTO
ATTIMIS
FAEDIS
COSTA
VERNASSO
CIVIDALE
UDINE
KOZBANA
PLAVE
BANJŠICE
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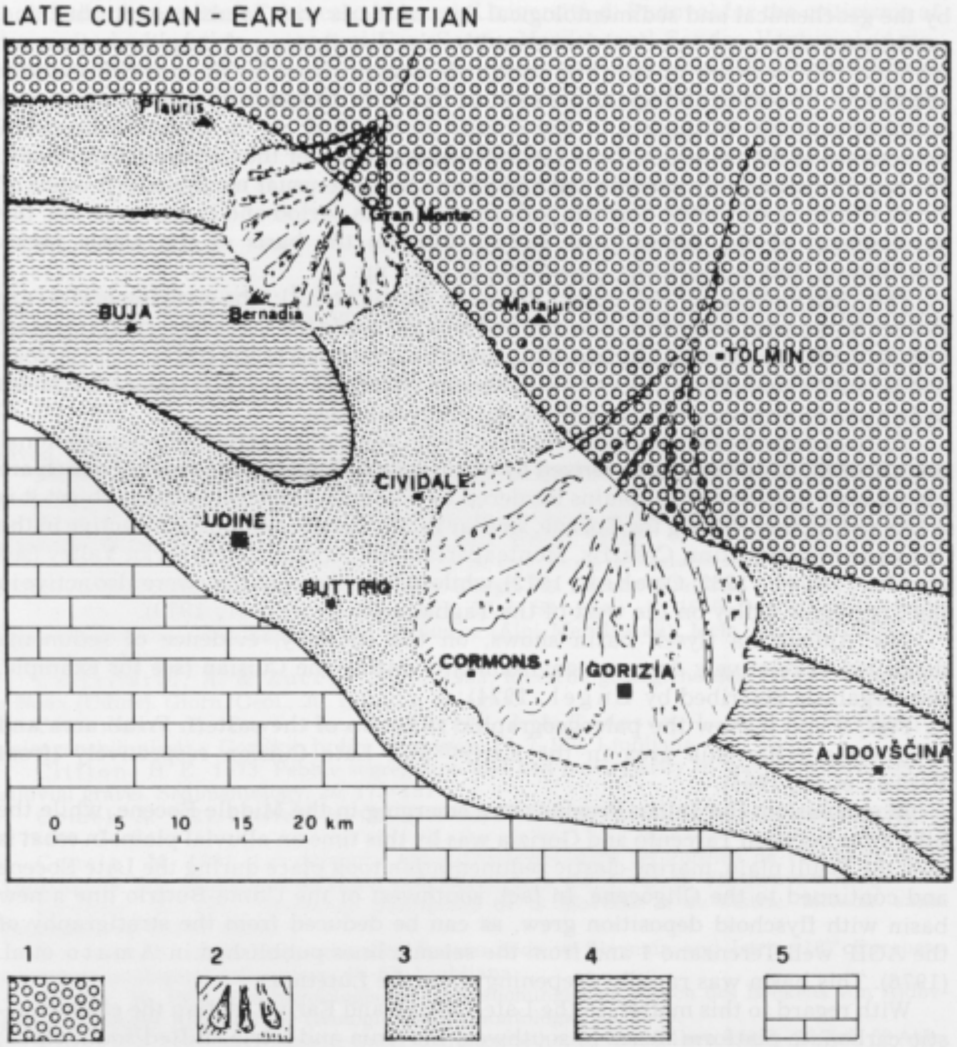

Fig. 9. Orientative paleogeographic scheme of the Late Cuisian – Early Lutetian (sources: Buser, 1973; Cousin, 1981; Drobne, 1977; Engel, 1974; Orehek, 1972; Pavlovec, 1963)

1. Areas emerging or already emerged, *2.* Submarine areas directly influenced by deltaic systems, *3.* Shallow areas affected by clastic inputs, *4.* Relatively deeper areas characterized by calcareous turbidites (megabeds) and sometimes by siliciclastic turbidites, *5.* Carbonate platform, locally emerged

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Fig. 8. Early Cuisian paleogeography

1. Carbonate platform, *2.* Area emerging or already emerged, *3.* Lower slope, *4.* Basin filled with turbidites and chaotic facies, *5.* Platform characterized by clastic input, *6.* Postulated position of the submerged ridge, *7.* "Friulan" inputs, *8.* "Prealpine" and "Carnic" inputs, *9.* Probable northeastern deltaic inputs by the geochemical and sedimentological data of marls with sandstone interbed and sandstones with marl interbed facies and by the distribution of conglomerates over the area. The decrease of the total carbonate content from N-NE to S-SW and the processing of sedimentological parameters in order to get information about the intensity and the variability of the energy levels allow us to assume a northern provenance of the materials (from the uplifted area), rather than a northwestern one. We cannot definitively exclude the hypothesis that the usual northwestern input of Friuli flyschoid turbiditic deposits influenced, in this period and in this area too, the development of the depositional system, but, on the basis of the whole facies distribution, this is pratically impossible to back up.

The distribution of the upper facies is asymmetrical; the conglomerates are thicker to the west (Cormons, Rosazzo and Noax)[10] while the sandstones outcrop most widely in the area around Gorizia. This could be connected to the system morphology and geometry and also to the erosive processes which occurred later on; coarse facies in fact are moderately well developed near Nova Gorica.

The last depositional environment here described corresponds to the conventional picture of those deltas, characterized by non coarse sedimentation, most of which are placed near narrow coastal plains bordered by young mountains. On this subject it is worth noting that, during the Eocene, similar fluvio-deltaic systems were active in the Tarcento area (Frattins, Cesarris, Monteaperta) and perhaps in the Pivka Valley (see also Pavlovec, 1963, Orehek, 1972), while in the Oligocene they were also active in the Tremugna Valley on the west of the Tagliamento R. (Sarti, 1979).

The Ajdovščina flysch basin shows, on the contrary, evidence of sediments deposited in relatively deep sea environments during the Cuisian (see for example, the megabeds described by Engel, 1974).

Figs. 8 and 9 show the paleogeographic situation of the eastern Friuli area and southwestern Slovenia area in the Early[11] and Late Cuisian respectively (from Pirini et al., 1986).

In conclusion, the Julian Prealps were emerging in the Middle Eocene, while the hilly strip between Tarcento and Gorizia was by this time an alluvial plain. In what is now the Friuli plain, marine clastic sedimentation took place during the Late Eocene and continued to the Oligocene. In fact, southwest of the Udine-Buttrio line a new basin with flyschoid deposition grew, as can be deduced from the stratigraphy of the AGIP well Terenzano 1 and from the seismic lines pubblished in Amato et al. (1976). This basin was rapidly deepening since the Lutetian.

With regard to this matter, in the Late Cuisian and Early Lutetian the characteristic carbonate platform facies in southwest Slovenia and Istria shifted southwards; the same occurred to the flysch basin of Central Istria (Drobne, 1977; Magdalenić, 1972).

Acknowledgements

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[10] We think that also the flyschoid deposits of the Rocca Bernarda hills (Martinis, 1955; Castellarin & Zucchi, 1963) a few km northwestward are related to the same fluvio-deltaic environment.

[11] Fig. 8 ilustrates the hypothesis that in the area between Kožbana and Plave the deposition of turbidites and other coarse sediments continued during the Cuisian.

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Literature

Amato, A., Barnaba, P. F., Finetti, I., Groppi, G., Martinis, B. & Muzzin, A. 1976, Geodynamic outline and seismicity of Friuli-Venetia Julia Region. Boll. Geof. Teor. Appl., *72*, 217–256, Trieste.

Bourgeois, J. 1980, A transgressive shelf sequence exhibiting hummocky stratification: the Cape Sebastian Sandstone (Upper Cretaceous), Southwestern Oregon. J. Sediment. Petrol., *50*, 681–702.

Buser, S. 1968, Osnovna geološka karta SFRJ, list Gorica, 1:100 000. Zvezni geološki zavod, Beograd.

Buser, S. 1973, Tolmač lista Gorica, Osnovna geološka karta SFRJ, 1:100 000. Zvezni geološki zavod, 50 pp., Beograd.

Buser, S. & Pavšič, J. 1978, Pomikanje krednega in paleogenskega flišnega bazena v zahodni Sloveniji. Zborn. radova 9. Jugosl. geol. kongr., 74–81.

Carobene, L. 1984, Morfologia, geologia ed evoluzione neotettonica dei rilievi collinari di Buttrio-Dolegna del Collio (Friuli orientale). Geogr. Fis. Dinam. Quatern., 7, 17–35.

Cason, C., Grandesso, P., Massari, F. & Stefani, C. 1980, Depositi deltizi nella molassa Cattiano – Burdigaliana del Bellunese (Alpi Meridionali). Mem. Ist. Geol. Min., *34*, 325–354, Padova.

Castellarin, A. & Zucchi, M. L. 1963, Ricerche geologiche nell Eocene di Rosazzo e Noax (Udine). Giorn. Geol., *30*, 199–213, Bologna.

Cimerman, F., Pavlovec, R., Pavšič, J. & Todesco, L. 1974, Biostratigrafija paleogenskih plasti v Goriških brdih. Geologija, *17*, 7–130, Ljubljana.

Clifton, H. E. 1973, Pebble segregation and bed lenticularity in wave – worked versus alluvial gravel. Sedimentology, *20*, 173–187.

Comel, A. 1927, I terreni del Collio. Studi Goriziani, vol. V. 120–144, 1 carta geologica 1:75 000, Gorizia.

Cousin, M. 1981, Les rapports Alpes–Dinarides dans les confins de l'Italie et de la Yougoslavie. Soc. géologique du Nord, publication n. 5, vol. I, vol. II. Villeneuve d'Ascq.

Drobne, K., 1977, Alvéolines paléogènes de la Slovénie et de l'Istrie. Mémoir. suiss. Paleontol., *99*, 3–174, Basel.

Drobne, K. 1979, Paleocene and Eocene beds in Slovenia and Istria. 16th European micropaleontological colloquium, 49–63, Ljubljana.

Engel, W. 1974, Sedimentologische Untersuchungen im Flysch des Beckens von Ajdovščina. Göttinger Arbeiten zur Geologie und Paläontologie, *16*, 1–65.

Flügel, E. 1981, Microfazielle Untersuchungsmethoden von Kalken. 454 S., 33 Taf., 68 Abb., 57 Tab., Berlin–Heidelberg–New York (Springer).

Homewood, P. & Allen, P. 1981, Wave, tide and current-controlled sandbodies of Miocene Molasse, Western Switzerland. Am. Ass. Petrol. Geol. Bull., *12*, 2534–2545.

Kuščer, D., Krošl-Kuščer, N. & Skaberne, D. 1976, Olistostrome v flišu pri Anhovem (zahodna Slovenija). 8. Jugosl. geol. kongres, Bled, 1–5 Oktober 1974.

Magdalenić, Z. 1972, Sedimentologija fliških naslaga srednje Istre. Acta geologica VII/2, 71–100, Tab. 1–9, Zagreb.

Marinoni, G. 1881–1886, Sui minerali del Friuli e sulle industrie relative. Ann. Statist. Prov. Udine, anno III, 82–197, 4 tab., anno IV, 19–84, Udine.

Martinis, B. 1955, Rilievo geologico di dettaglio dei colli di Rocca Bernarda (Udine). Atti I. conv. Nat. Friul., 403–438, Udine.

Martinis, B. 1962, Ricerche geologiche e paleontologiche sulla regione compresa tra il fiume Judrio ed il fiume Timavo (Friuli orientale). Riv. It. Pal. e Strat. Mem. VIII, 1–244, Milano.

Mutti, E. & Ricci Lucchi, F. 1972, Le torbiditi dell'Appennino settentrionale: introduzione all'analisi di facies. Mem. Soc. Geol. It., v. 11, 161–199.

Nardon, S. 1982, Ipotesi di ricostruzione paleogeografica dell'area compresa tra il f. Judrio e il f. Isonzo. Tesi inedita. Università di Trieste.

Orehek, S. 1972, Eocenski fliš Pivške Kotline in Brkinov. VII Kongres geologa SFRJ, Predavanja II, 253–270, Zagreb.

Pavlovec, R. 1963, Stratigrafski razvoj starejšega paleogena v južnozahodni Sloveniji. Razprave SAZU, IV, 7, 419–556, Ljubljana.

Pavlovec, R. 1969, Istrske numulitine s posebnim ozirom na filogenezo in paleoekologijo. Razprave SAZU, IV. raz., 12, 153–206, tab. 1–13, Ljubljana.

Pavšič, J. 1977, Nanoplankton v zgornjekrednih in paleocenskih plasteh na Goriškem. Geologija, 20, 33–64, Ljubljana.

Pavšič, J. 1979, Zgornjekredni in paleocenski apneni nanoplankton v Posočju. Geologija 22/2, 225–276, Ljubljana.

Pavšič, J. 1985, Nanoplanktonska stratigrafija krednega in paleocenskega fliša v okolici Breginja. Razp. IV, Raz. SAZU, 26, 231–246, Ljubljana.

Piccoli, G. & Proto Decima, F. 1969, Ricerche biostratigrafiche sui depositi flyschoidi della regione adriatica settentrionale e orientale. Mem. Ist. Geol. Min. 27, 1–23, tav. 1–3, Padova.

Pirini Radrizzani, C., Tunis, G. & Venturini, S. 1986, Biostratigrafia e paleogeografia dell'area sudoccidentale dell'anticlinale M. Mia–M. Mataiur (Prealpi Giulie). Riv. It. Pal. Strat., 92, 3, 327–382, Milano.

Placer, L. 1981, Geološka zgradba jugozahodne Slovenije. Geologija, 24/1, 27–60, Ljubljana.

Plint, A. G. 1983, Facies environments and sedimentary cycles in the Middle Eocene Bracklesham Formation of the Hampshire Basin: evidence for global sea-level changes? Sedimentology, 30, 625–653.

Ricci Lucchi, F., Colella, A., Ori, G. G. & Ogliani, F. 1981, Pliocene fan deltas of the Intra-Appenninic Basin. Bologna IAS 2nd European Regional Meeting, Excursion Guidebook, 79–162.

Sarntheim, M. & Walger, E. 1973, Classification of modern marl sediments on the Persian Gulf by factor analysis. In: PURSER B. H. (ed.): The Persian Gulf, 81–97, New York (Springer).

Sarti, M. 1980, Il Paleogene della Val Tremugna (Prealpi Carniche) Boll. Soc. Geol. Ital., 98, 87–108, Roma.

Seguret, M., Labaume, P. & Madariaga, R. 1984, Eocene seismicity in the Pyrenees from megaturbidites of the south pyrenean basin (Spain). Mar. Geol., 55, 117–131.

Seilacher, A. 1967, Bathymetry of trace fossils. Mar. Geol. 5, 413–428.

Skaberne, D. 1987, The Paleocene megaturbidites – Anhovo. Guidebook of Excursions, International Symposium on the "Evolution of the karstic carbonate platform", 5th and 6th June 1987 E. Friuli, Karst of Gorizia and of W. Slovenia, 37–45.

Šribar, L. 1965, Meja med krednimi in terciarnimi skladi v Goriških Brdih. Geologija, 8, 121–129, Ljubljana.

Taramelli, T. 1870, Sulla formazione eocenica del Friuli. Atti Acc. vd. ser. 2°, vol. I, 25–65, Udine.

Tunis, G. 1976, Analisi di facies del flysch del Friuli orientale a S. E. del torrente Chiarò di Torreano. Tesi inedita. Università di Trieste.

Tunis, G. & Venturini, S. 1984, Stratigrafia e sedimentologia del flysch maastrichtiano – paleocenico del Friuli orientale – Gortania, 6, 5–58 Udine.

Tunis, G. & Venturini, S. 1985, Flysch of Eastern Friuli: a preliminary approach to paleoenvironmental reconstruction. Rud. Met. Zbornik, 32, 1–2, 3–9.

Vail, P. R., Mitchum, R. M. & Thompson, S. 1977, Seismic stratigraphy and global changes of sea level, part. 4: Global cycles of relative changes of sea level. In: Seismic stratigraphy – application to hydrocarbon exploration (Ed. by C. E. Payton). Mem. Am. Ass. Petrol. Geol. Tulsa, 26, 83–87.

Venzo, G. A. & Brambati, A. 1969, Prime osservazioni sedimentologiche sul flysch friulano. St. Trent. Sc. Nat. Sez. A., vol. 46, n. 1, 3–10, Trento.

Wescott, W. A. & Ethridge, F. G. 1980, Fan -delta sedimentology and tectonic setting – Yallahs Fan Delta, southeast Jamaica. Bull. Am. Ass. Petrol. Geol. 64, 374–399.

Wescott, W. A. & Ethridge, F. G. 1983, Eocene fan delta – submarine fan deposition in the Wag Water Through, east central Jamaica. Sedimentology, 30, 235–247.