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THE RECORD OF DISAPPEARED OR BURIED GEOLOGICAL HISTORIES IN OLISTOLITHS OF THE FLYSCH DEL GRIVÒ (EASTERN FRIULI, NE ITALY)

LA DOCUMENTAZIONE DI STORIE GEOLOGICHE SCOMPARSE O SEPOLTE NEGLI OLISTOLITI DEL FLYSCH DEL GRIVÒ (FRIULI ORIENTALE, NE ITALIA)

Abstract - In the calciclastic-carbonatic turbiditic unit of Flysch del Grivò (Upper Paleocene-Lower Eocene) of the Julian Prealps a number of very thick carbonate resedimentations (megabeds) are present. The study of some olistoliths and many large carbonate clast in the some megabeds allowed the recognition of deposits and facies often not found *in situ,* and to hypothesize the source areas of these clasts. The long memory of these clasts opens up broad research perspectives from stratigraphic, palaeogeographic, palaeotectonical and palaeontological points of view.
Key words: Olistoliths, Megabeds, Flysch del Grivò, Cretaceous, Paleocene, Eocene, Julian Prealps.

Riassunto breve - *Nell'unità torbiditica calciclastico-carbonatica del Flysch del Grivò (Paleocene superiore-Eocene inferiore) delle Prealpi Giulie sono presenti numerose risedimentazioni carbonatiche (megabanchi=megabeds) di grande spessore. Lo studio di alcuni olistoliti e di numerosi clasti carbonatici di grandi dimensioni presenti in alcuni megabanchi ha consentito il riconoscimento di depositi e facies spesso non rinvenuti* in situ*, e di ipotizzare le aree di origine di tali clasti. La lunga memoria di questi clasti apre ampie prospettive di ricerca dal punto di vista stratigrafico, paleogeografico, paleotettonico e paleontologico.*
Parole chiave: *Olistoliti, Megabanchi, Flysch del Grivò, Cretaceo, Paleocene, Eocene, Prealpi Giulie.*

Introduction

The Julian Basin was a WNW-ESE elongated basin located in the Julian Prealps of eastern Italy and western Slovenia during the Jurassic, Cretaceous, Paleocene and Eocene. Along its southern border, this basin was delimited by a carbonate platform (Friuli Platform-FCP). Starting from Late Campanian and until Middle Eocene, the basin was characterized by turbiditic systems, with mixed siliciclastic/calcilastic deposits. Tectonics caused the shifting of the southern border of the Julian Basin to a SW direction, accompanied by the dismantling and withdrawal of the Friuli Platform margin. The FCP was the major source of carbonate clasts: within the stratigraphic framework of the Julian Basin, deposits of carbonate megabeds and thick carbonate beds are a clear evidence of tectonic activity along the margin and the slope of the platform. Siliciclastic detritus, mixed with other carbonate clasts, instead, came from N and NW, as indicated by palaeocurrent directions. The carbonate megabeds represent regional stratigraphic markers especially in the Upper Paleocene and Lower Eocene turbiditic system, when the dismantling of the Friuli Platform reaches its acme; during this time span, the typical "turbidites with megabeds" sequence is represented by the Flysch del Grivò Formation (Tunis & Venturini 1992). During the Early Lutetian a rapid progradation of prodelta, front and delta plain deposits occurred from the North, probably related to a tectonic uplift (Pirini et al. 1986).

All the coarse and fine clastic inputs in the basin record what occoured in the northern and southern areas, where the related deposits were often dismantled or today are buried. So sometimes they represent the memory of geological events no longer recognizable in any other way.

Geological framework.

In the southern border of the Julian Prealps (Fig. 1), during the Late Campanian-Maastrichtian the margin

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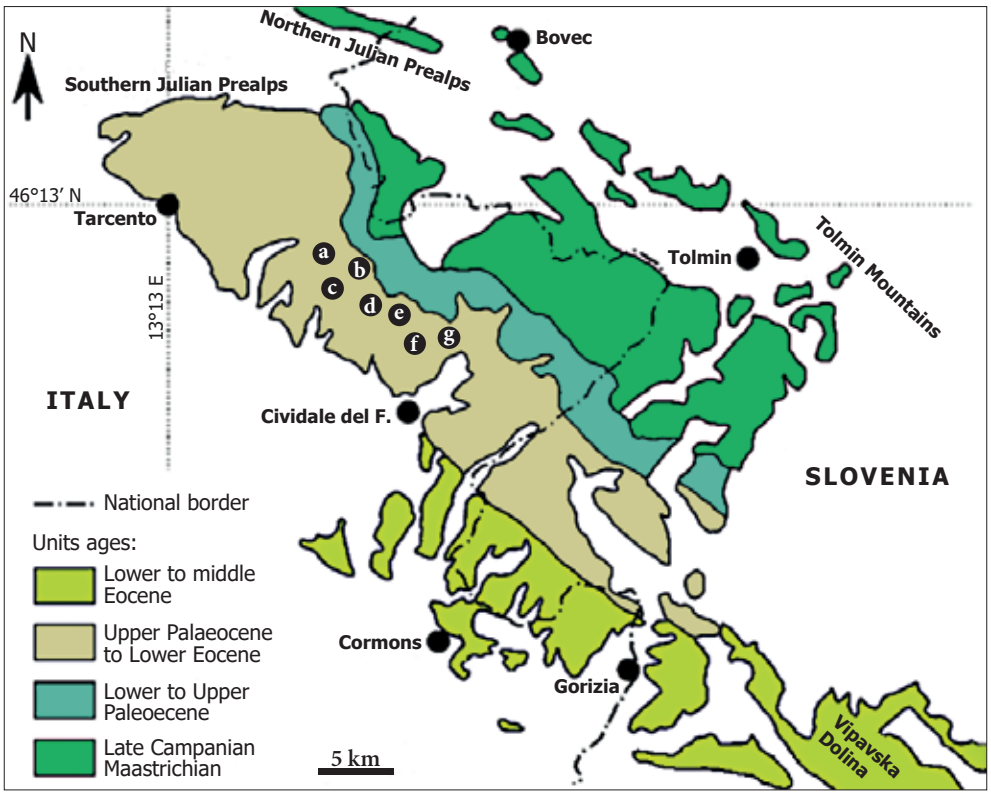

Fig. 1 - Flysch deposits in the Julian Basin (from Bernardi et al. 2022, modified). Letters indicate the position of the sections in Fig. 2.
- *I depositi di Flysch nel Bacino Giulio (da Bernardi et al. 2022, modificato). Le lettere indicano la posizione delle sezioni di Fig. 2.*

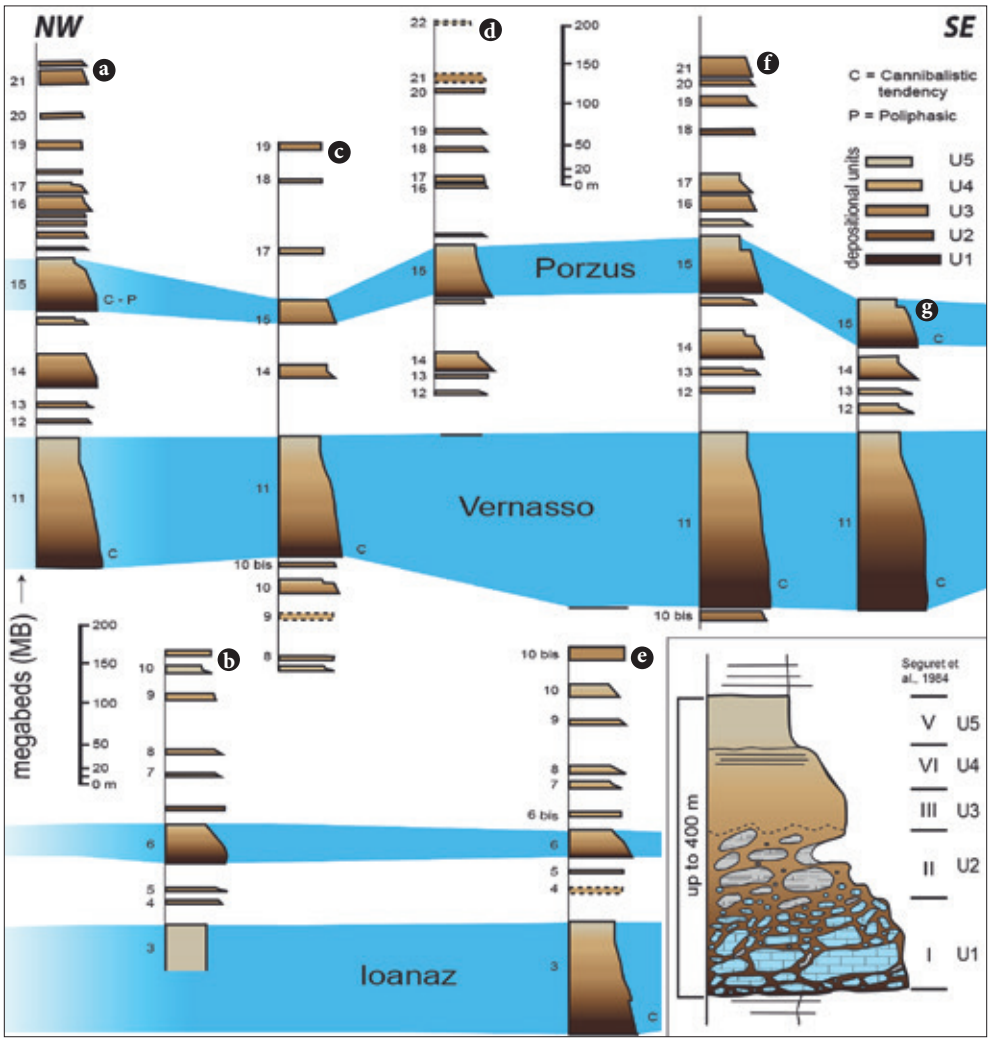

Fig. 2 - Flysch del Grivò Fm. of the Julian Prealps, with megabeds correlations (from Ogata et al. 2014, modified).
- *Formazione del Flysch del Grivò nelle Prealpi Giulie, con le correlazioni fra i megabeds (da Ogata et al. 2014, modificato).*

of the Friuli carbonate platform (FCP) was affected by intense tectonic activity, with partial dismantling and consequent underwater slides of carbonate clasts coming from the platform; submarine canyons have been formed on the escarpment. The southern slope, incised by paleocanyons, of the Julian Basin during the Late Paleocene-Early Eocene was progressively covered by siliciclastic turbidites (Fig. 1), with a number of very thick carbonate deposits embedded. These megabeds, characterized by basal carbonate megabreccias, are modernly designated by the acronym MTDs, and were produced by repeated catastrophic submarine landslides in which large sectors of the FCP collapsed.

Previous works points out toward multiple regional tectonic triggering events affecting at that time the FCP which was hosted by the foreland passive margin of the Julian Basin. The megabeds, despite significant thickness variability, are laterally extensive and can be correlated at the scale of the entire basin. The internal organization of the megabeds show five units but this study concerns mostly unit 1 where out-size blocks or olistoliths have been found (Fig. 2).

As fore-mentioned, the portion linking the Cretaceous and Paleocene platform to the basin is largely missing preventing the direct reconstruction of the platform margin, thus olistoliths represent the key component for understanding the stratigraphic evolution of the submarine margin of the FCP. The olistoliths derived by resedimentation of shallow marine FCP and their lithology and fossil content can sometimes be recognized in the Cretaceous successions of the near areas of Mt. Bernadia, Judrio valley, Mt. Sabotino/Sabotin, Isonzo/Soca valley and also in the Paleocene strata of Gorizia Karst but often the out-size blocks are derived from hiterto unidentified remote areas.

Due to the complexity and breadth of the research, this study is limited only to a number of olistoliths containing significant macrofossils and in particular it is addressed mainly to the basal unit of Vernasso megabed (MB 11; Fig. 2). Three examples belonging to the Flysch del Grivò Formation (FG) are selected herein, i. e. Vernasso, Vigant and Montenars areas. The last two being younger than MB 11.

Moreover, a short note about the Rio Zimor olistostrome (upper part of FG) has been added.

The megabeds of Flysch del Grivò and Flysch di Masarolis formations have been recently mapped in detail for the Julian Prealps sector between Mt. Bernadia and Judrio valley (Pini & Ponton 2023). Part of the western portion of Julian Prealps is included in the geological sheet 1:50.000 Gemona del Friuli (Zanferrari et al. 2013), but there is no particular detail for the trend and stratigraphy of the megabeds.

This note is an extension of what was presented during the workshop "Geology and Paleontology of Friuli and adjacent areas", organized by the Museo Friulano di Storia Naturale of Udine, in memory of Luca Simonetto (Simonetto et al. 2023)

Vernasso olistoliths

The Vernasso Quarry fossiliferous site (Cividale del Friuli-San Pietro al Natisone; Fig. 3) represents a geological historical case attesting researches carried out by scholars over the last 250 years whose memories are preserved in books and in the rich fossil collections of

Fig. 3 - The "megabed 11" of the Flysch del Grivò, cut by quarry works (Vernasso Quarry, Udine). On the left, the transition to Flysch is evident.
- *Il "megabed 11" del Flysch del Grivò, tagliato dai lavori di cava (Cava di Vernasso, Udine). Sulla sinistra si nota il passaggio al "flysch".*

Fig. 4 - Location of the sites of Cornappo Valley, Vernasso Quarry, and Mt Santo / Sveta Gora. Probable extension of the Hauterivian- Barremian fossiliferous facies in a back sector of the FCP margin, in ocher. Red arrow indicates the possible area of provenance of the Hauterivian-Barremian olistoliths with fishes.
- *Localizzazione dei siti di Valle Cornappo, Cava di Vernasso e Monte Santo /Sveta Gora. In ocra, la probabile estensione della facies fossilifera dell'Hauteriviano-Barremiano in un settore posteriore del margine FCP. La freccia rossa indica la possibile area di provenienza degli olistoliti hauteriviano-barremiani a pesci.*

Fig. 5 - To the left: Ammonite (Placenticeratidae ?) from the Campanian olistolith with plants and mollusks, Vernasso quarry (from Mietto et al. 2008). For comparison, to the right: Placenticeratidae, from the Tomaj Lm., Lower Campanian, Kazlie, Slovenian Kras (from Jurkovsek et al. 2013).
- *A sinistra: Ammonite (Placenticeratidae ?) dall'olistolite campaniano con piante e molluschi, Cava di Vernasso (da Mietto et al. 2008). Per confronto, a destra: Placenticeratidae, dal Tomaj Lm., Campaniano inferiore, Kazlie, Carso sloveno (da Jurkovsek et al. 2013).*

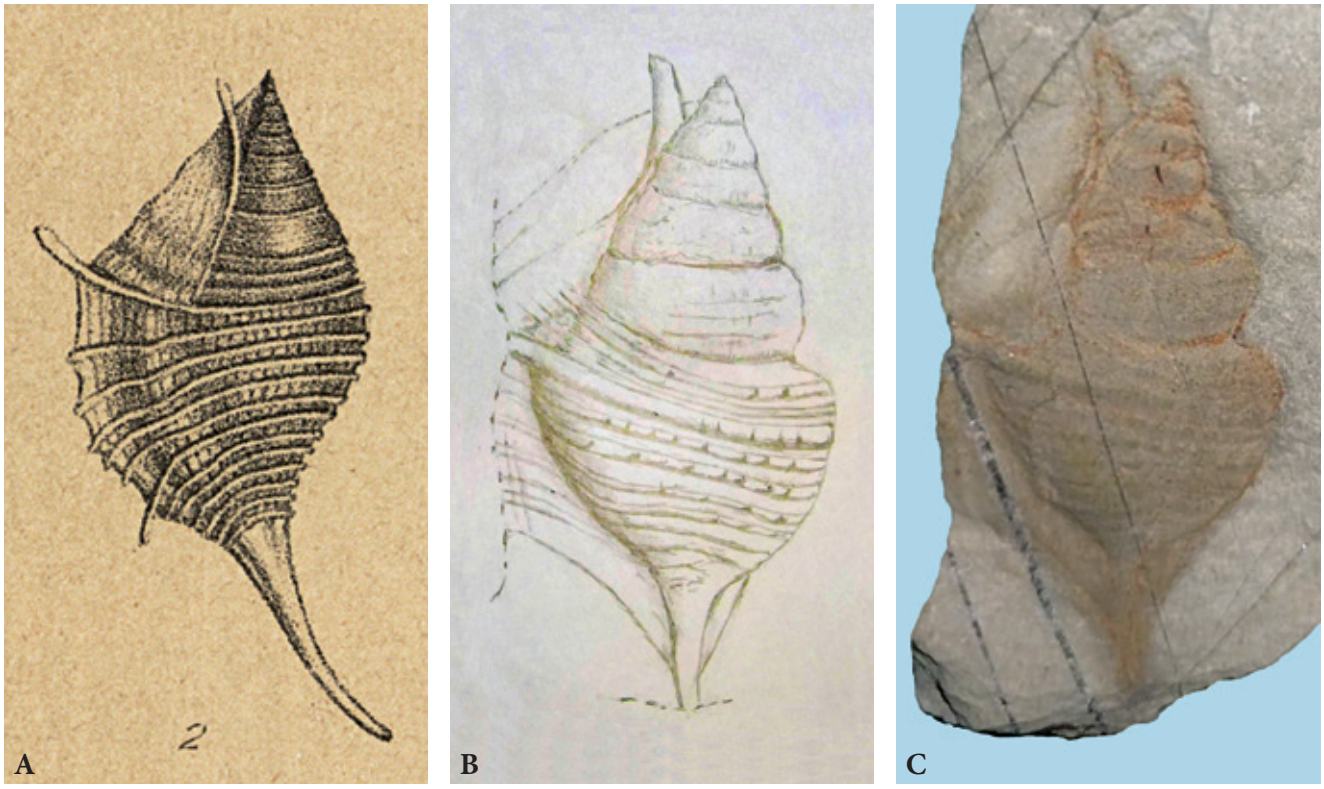

Fig. 6 - C*eratosiphon carolifabricii.* A) drawing reconstructed from incomplete specimens (from Tommasi 1891, pl 1, fig. 1). B) drawing of specimen MFSNgp 35989, which better responds with the descriprion made by the fore-mentioned Author; the height of the specimen is about 3,5 cm, C) the specimen MFSNgp 35989.
- Ceratosiphon carolifabricii. *A) disegno ricostruttivo sulla base di esemplari incompleti (da Tommasi 1891, tav. 1, fig. 1). B) disegno dell'esemplare MFSNgp 35989 che meglio risponde alla descrizione fatta dall'Autore citato; l'altezza dell'esemplare è di circa 3,5 cm. C) l'esemplare MFSNgp 35989.*

the Museo Friulano di Storia Naturale (MFSN). In fact, the first historical report of the Vernasso site dates back to 1776, as reported in the Epistolario of G. Festari (published in 1862). Moreover, the Vernasso megabed shows the widest lithological variety among the FG.

The finding of *Amiopsis* cf. *prisca* (Amalfitano et al. 2022) in one block with abundant Pycnodontiformes dated back to Hauterivian-Barremian is significant. The presence of *Amiopsis* sp. was reported by Dalla Vecchia et al. (2007) in the Cornappo Valley and also at the base of Sveta Gora, a few km north of Nova Gorica (Gorjanović-Kramberger 1895). The last two sites and the olistolith of Vernasso are very likely coeval (unpublished surveys on Sveta Gora area) and a significant areal extension of the fossiliferous facies in a back-sector of the FCP margin can be assumed (Fig. 4). The afore-mentioned Hauterivian-Barremian facies were found neither in the outer-most sector of FCP (i.e. Judrio valley) nor in the inner areas of the platform (Slovenia Karst).

More information about fish fauna of Vernasso Quarry are given in a recent pubblication (Amalfitano et al. 2023).

One large olistolith of Vernasso Quarry is formed by fine grained limestones with remains of continental flora (Bozzi 1891) and an association with benthic mollusks (Tommasi 1891), also including ammonites (absolutely very rare in the Friuli Cretaceous successions). This facies was previously attributed to the "Early Senonian" (Tommasi 1891) or Coniacian-Santonian (Gomez et al. 2002); based on new calcareous nannofossil analysis, this limestone is ascribable to the Campanian (Roghi et al. 2023). This facies represents an "*unicum*" in Friuli and in the in the Southern Alps, and recalls the Tomaj limestone of the northeastern border of the Slovenian Karst (Jurkovšek et al. 1996). Due to the presence of Placenticeratidae of the *milleribidorsatum* group (Summersberger et al. 1996), Tomaj limestone has been attributed to the Lower Campanian; the palaeoenvironment is anoxic and benthic mollusks are absent. At Vernasso a number of small and flat ammonites have been discovered (Fig. 5), comparable to the Placenticeratidae of Tomaj, so a stratigraphic correlation of these facies can be suggested.

The presence of a peculiar Aporrhaidae gastropod, represented by *Ceratosiphon carolifabricii* Tommasi (1891), in this Campanian limestone is to note. This species is known in the literature only on the basis of the drawing published by Tommasi (Fig. 6), reconstructed from incomplete specimens. The types were originally deposited in the collection of the Museum of the Technical Institute of Udine (Gabinetto di Storia Naturale

Fig. 7 - Palaeogeography and facies during Lower Campanian. Red arrow indicates the possible area of provenace of the olistolith with phyllites and mollusks.
- *Paleogeografia e facies durante il Campaniano inferiore. La freccia rossa indica la possibile area di provenienza dell'olistolite a filliti e molluschi.*

Fig. 8 - Palaeogeography and facies at the Paleocene-Eocene boundary (close to Megabed 8). Probable area of provenance (red circle) for the Vernasso Paleocene olistoliths (mainly limestones with corals, algae and micro-foraminfers).
- *Paleogeografia e facies al passaggio Paleocene-Eocene (Mb 8). Il circoletto rosso indica la probabile area di provenienza degli olistoliti del Paleocene di Vernasso (in prevalenza calcari con coralli, alghe e microforaminferi).*

del Regio Istituto Tecnico di Udine). Their current location is unknown. Vernasso quarry, as far as is known, is the only locality where this species has been found. No other Aporrhaidae species are known in the Late Cretaceous of the Southern Alps and perhaps also of the Apennines. Moreover, the Campanian Aporrhaidae are all over very rare and little known. Some specimens from Vernasso are stored in the MFSN (nn. MFSNgp 35989, MFSNgp 36367, MFSNgp 35372).

The description of *Ceratosiphon carolifabricii* (Tommasi 1891, pag. 1095; written in Italian) reports: "Short shell, composed of 9-10 longitudinally rib-shaped whorls. The last whorl has two more raised ribs than the others in the form of a keel and between them 5 to 8 smaller ones are compressed. The lip is enough expanded, embracing the whorls up to the apex, and presents, including the canal, four digits: a front one formed by the canal, which is thin, almost as long as the shell and slightly bent to the left, a posterior one, which borders the spiral in its entire length and two intermediate ones, divergent, in continuation of the two keels. The ribs of the last whorl are a bit knotty. The other whorls also have traces of ribs, perhaps crossed by transverse folds". The specimen MFSNgp 35989 fits well with this description, differently from the figure of Tommasi. The finding of the new specimens deposited in MFSN (and probably in other museums) could allow a revision of this form, with possible phylogenetic, biogeographical and palaeoenvironmental implications. The same goes for the rest of the faunal association with mollusks.

The original palaeogeographic location of the Vernasso olistolith is unknown, but due to the presence of pelagic fauna it is hypothesized an upper slope environment, outside of the northeastern margin of FCP, a few km south of Cividale area (Fig. 7), now covered by alluvial deposits and flysch. Eight chilometers to the SSE, in southern Judrio valley (Northeast of Albana, Prepotto), the Lower Campanian association with plants, mollusks and ammonites is lacking, probably due to erosive phenomena occoured between the Lowermost Campanian *Keramosphaerina* horizon and the Upper Campanian Scaglia with planktonic Foraminifera.

Other small blocks of Vernasso characterized by limestones with corals, red algae, Dasycladaceae, mollusks, benthic foraminifers and miliolids are dated back to the Upper Paleocene-Lowermost Eocene. These large-sized clasts could, in comparison with the previous ones, may have derived from more southern zones of FCP (Fig. 8) along a strip that extended from Cividale, Medea hill to Mt. San Michele including the buried strata of the Friuli Plain (Cargnacco 1 and Buttrio 1 wells). The hypothesized palaeogeographic context is supported by the litho- and biofacies of large clasts examined by Tunis & Venturini (1992). Furthermore, it is pointed out that large Paleocene olistoliths seem to be absent or at least very rare in the Vernasso site.

Vigant olistoliths

An out-sized block at the base of a megabed outcropping near Borgo Vigant (Nimis, north of Mt. Bernadia; Fig. 9) was examined by Dalla Vecchia et al. (2004). *Orbitoides* sp. and *Siderolites calcitrapoides* allow to

Fig. 9 - Borgo Vigant (Nimis, Udine). In this olistolith, "collapsed" in the flysch, a rich rudists fauna have been found.
- *Borgo Vigant (Nimis, Udine). In questo olistolite, "franato" nel flysch, è stata rinvenuta una ricca fauna a rudiste.*

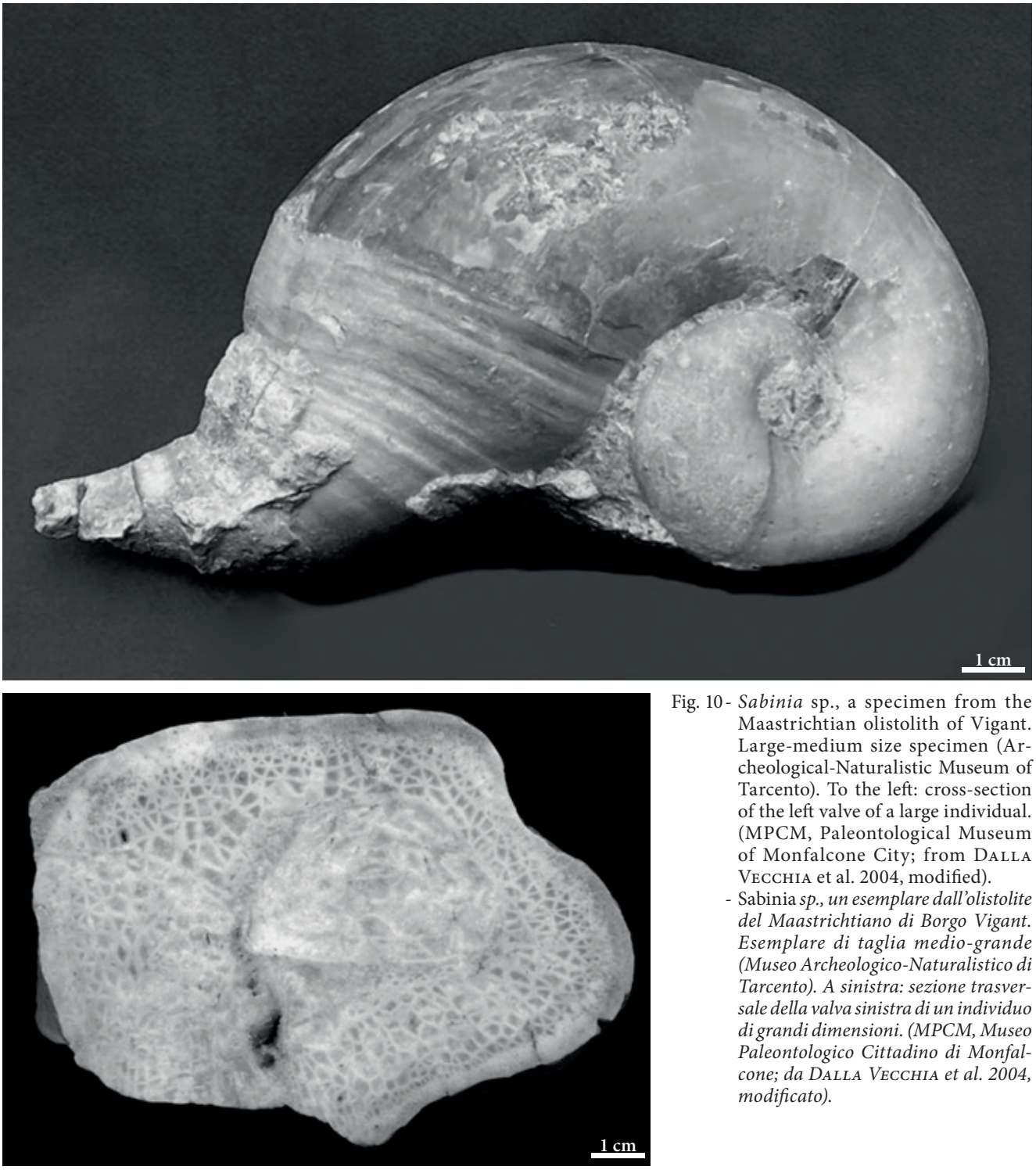

Fig. 10 - *Sabinia* sp., a specimen from the Maastrichtian olistolith of Vigant. Large-medium size specimen (Archeological-Naturalistic Museum of Tarcento). To the left: cross-section of the left valve of a large individual. (MPCM, Paleontological Museum of Monfalcone City; from Dalla Vecchia et al. 2004, modified).
- Sabinia *sp., un esemplare dall'olistolite del Maastrichtiano di Borgo Vigant. Esemplare di taglia medio-grande (Museo Archeologico-Naturalistico di Tarcento). A sinistra: sezione trasversale della valva sinistra di un individuo di grandi dimensioni. (MPCM, Museo Paleontologico Cittadino di Monfalcone; da Dalla Vecchia et al. 2004, modificato).*

date the block to the Maastrichtian. The macrofauna is dominated by an interesting previously unknown rudist association. Among rudists, the genus *Sabinia* is common (Fig. 10), in association with *Hippurites-Hippuritella*, *Biradiolites*, *Lapeirousia*, *Praelaperousia* and probably *Rajka*. Small bivalves, gastropods, Terebratulids, Decapods and corals as well as rudists have been found. This rudist association is not present in the Karst region because the time-equivalent strata are characterized by very different facies (Liburnian Beds). In the Carnic Prealps (Mt. Jouf and Mt. Fara) an association of Lower Maastrichtian rudists has been reported, with *Joufia*, *Colveraia*, *Pseudopolyconites*, *Sauvagesia*, *Katzeria*, *Pironaea*, *Hippurites*, *Sabinia*, *Plagyoptychus*, *Apricardia* (Swinburne & Noacco 1993), largely different from that of the Vigant block.

The areas of Mt. Bernadia and Judrio valley are excluded for the origin of the Vigant olistolith so long as the Maastrichtian deposits therein are absent (eroded) or represented by Scaglia or by resedimented bioclastic

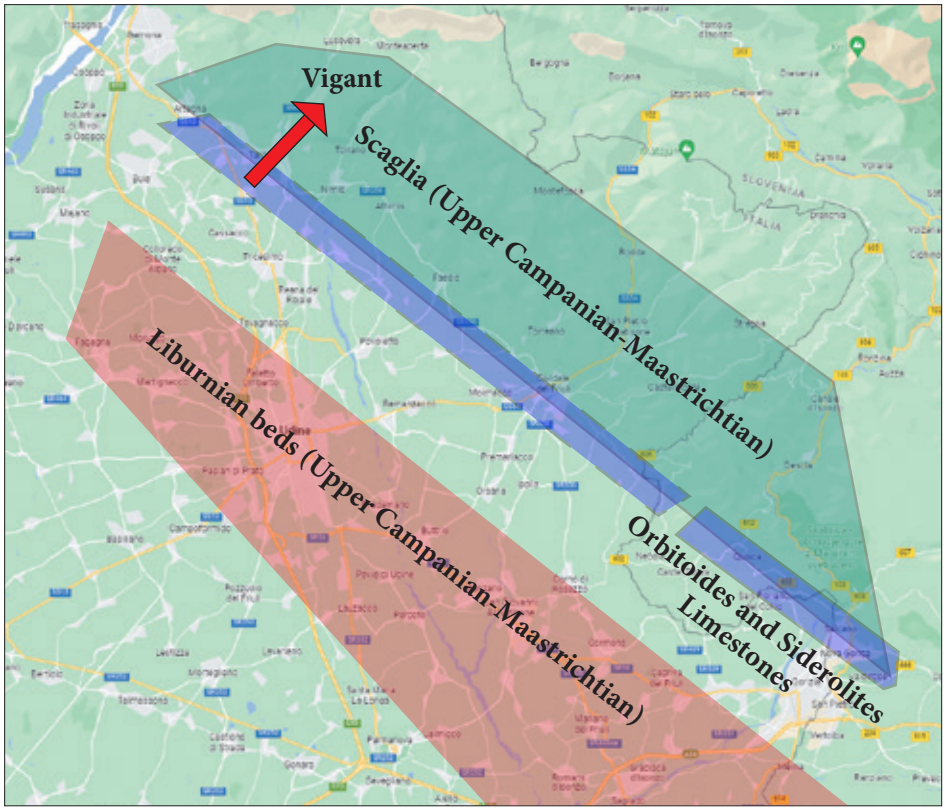

Fig. 11 - Palaeogeographic scheme and facies during Upper Campanian-Maastrichtian. The red arrow indicates the possible area of provenance of the Maastricthian olistolith of Vigant.
- *Paleogeografia e facies durante il Campaniano Superiore-Maastrichtiano. La freccia rossa indica la possibile area di provenienza dell'olistolite maastrichtiano di Vigant.*

Fig. 12 - Probable area of provenance (red circle) for the Vigant Paleocene olistoliths. Base map: palaeogeography and facies at the Paleocene-Eocene boundary.
- *Il circoletto rosso indica la probabile area di provenienza degli olistoliti del Paleocene di Borgo Vigant. Mappa base: paleogeografia e facies al passaggio Paleocene-Eocene.*

limestones, as for instance at Kozbana (Goriška Brda, Slovenia) and Mt. Sabotino. This block bears witness to a faunal association unknown in the FCP but probably existing in areas southward of Bernadia Mts., may be in neighbouring Tarcento area (Fig. 11).

Minor blocks with corals, algae, benthic foraminifers and bryozoans attributed to the Upper Paleocene-Lowermost Eocene and other clasts with apparently similar facies to those of the Liburnian beds support a provenance from not visible southern areas buried by alluvial and flysch deposits (Fig. 12). Palaeocanyons which formed during the upper Campanian-Lower Maastrichtian on the escarpments of FCP may have been the most important route of the blocks (Venturini & Tunis 1998).

Montenars olistoliths

Olistoliths and large sized blocks in the area of Montenars are characterized by rich macrofaunas and flora, the rudists in particular are very abundant (Tab. I).

The paleontological interest of the Montenars area and, above all, of the carbonate banks outcropping there, emerged mainly after the reports of Ruggero Tonello (Dalla Vecchia et al. 2003; Fig. 13), whose rich collection, after the passing of the passionate paleontophile, was entrusted to the MFSN in Udine and is currently being studied, in particular for the fish faunas (Dalla Vecchia et al. 2023) and rudists (Fig. 14; Tarlao et al. in prep.).

In particular, the finding of *Joufia serbica* Milovanovici is interesting (Fig. 14/A). This rudist was historically attributed to *Kuhenia serbica* and other nominal radiolitid genera and species, but Özer et al. (2021) re-assigned this rudist to the genus *Joufia* Boehm after revision of three radiolitid genera. The fore-mentioned authors (2021) recognized in their revision of the Joufia genus the *Joufia milovanovici* (Šliskovič, 1968) species (Fig. 14/D), previously attributed to different genera and species.

An example of caprinid doubtfully attributed to *Caprina adversa* (Fig. 14/E) was found admist the blocks of Clapon (Tab. I). *C. adversa* is a rare rudist recovered in Italy only near Avezzano and Tresacco (L'Aquila, Abruzzo).

The finding of an example of *Pironaea* sp. in the Plazzaris area is noteworthy significant. Historically, this rudist was first collected by Pirona in the blocks of the Vernasso megabed widely outcropping along the Subit-Platischis road (Fig. 12). Pirona (1868) assigned it the name *Hippurites polystyla* n. sp. in a short communication at the meeting of the Società Italiana di Scienze Naturali (Fig. 15). Meneghini (1868) in the same session of the fore-mentioned Society proposed the new genus *Pironaea* for this specimen in honor of

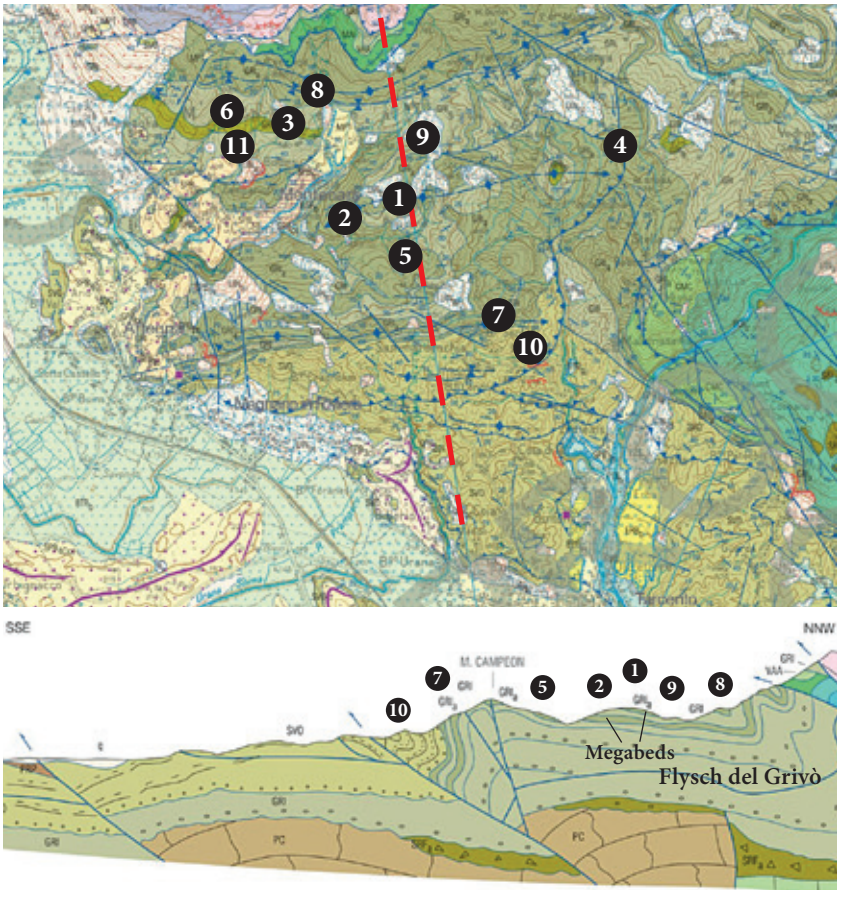

Fig. 13 - Geological map of the area between Tarcento and Montenars (detail from Zanferrari et al. 2013; modified). Red dotted line: trace of the geological section. Numbers: fossiliferous sites explored by Ruggero Tonello. 1 - Plazzaris; 2 - Plazzaris-Fese; 3 - Prato Martini-Montenars?; 4 - Stella; 5 - Clapon; 6 - Rio Premalina; 7 - Socret; 8 - Orvenco; 9 - Ronc; 10 - Sammardenchia: 11 - Crist. Below: geological section NNW-SSE (detail from Zanferrari et al. 2013; modified), with the location of some fossiliferous sites. GRI: Flysch del Grivò. GRIa: megabeds. SVO: Marne ed arenarie di Savorgnano (previously Flysch di Cormons in this area).

- *Carta geologica dell'area tra Tarcento e Montenars (dettaglio da Zanferrari et al. 2013; modificata). Linea tratteggiata rossa: traccia della sezione geologica. I numeri indicano i siti fossiliferi esplorati da Ruggero Tonello (vedi sopra). Sotto: sezione geologica NNW-SSE (particolare da Zanferrari et al. 2013; modificato), con l'ubicazione di alcuni siti fossiliferi. GRI: Flysch del Grivò. GRIa: megabeds. SVO: Marne e arenarie di Savorgnano (già Flysch di Cormons in questa zona).*

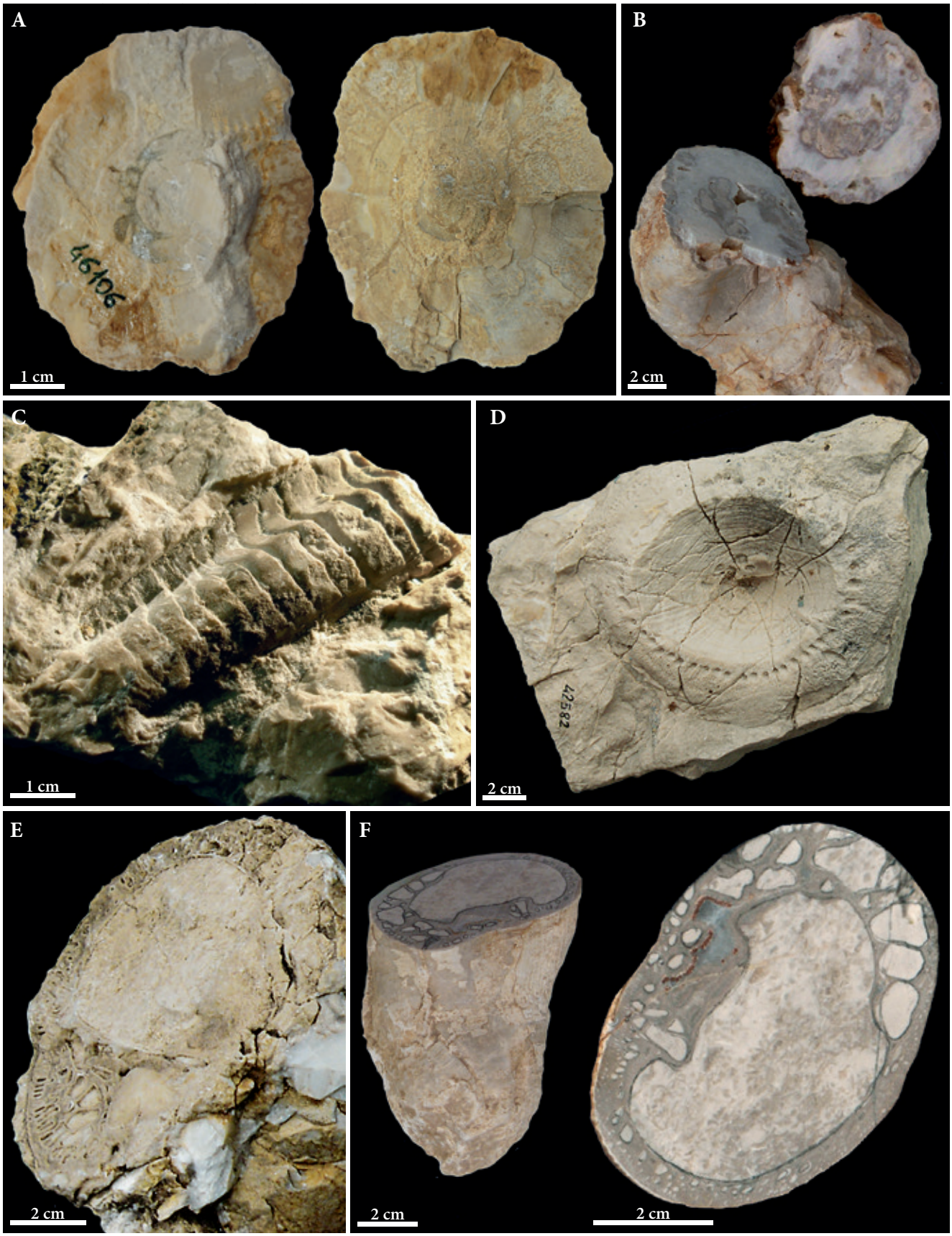

Fig. 14 - Rudists from the Montenars olistoliths. A) *Joufia serbica*, left valve, bottom (left) and top (right) view; MFSNgp 46106, B) *Sabinia aniensis*, left valve and detail of its transversal section; MFSNgp 43084. C) *Radiolites gastaldianus*, left valve; MFSNgp 46262; D) *Joufia milovanovici*, left valve; MFSNgp 42582. E) *Caprina adversa*, right valve; MFSNgp 45083. F) *Caprinula boissyi*, right valve and detail of its transversal section; MFSNgp 43078.

- *Rudiste provenienti dagli olistoliti di Montenars. A)* Joufia serbica, *valva sinistra, vista da sotto (a sinistra) e da sopra (a destra); MFSNgp 46106, B)* Sabinia aniensis, *left valve and detail of its transversal section; MFSNgp 43084. C)* Radiolites gastaldianus, *valva sinistra; MFSNgp 46262. D)* Joufia milovanovici, *valva sinistra; MFSNgp 42582. E)* Caprina adversa, *valva destra; MFSNgp 45083. F)* Caprinula boissyi, *valva destra e dettaglio della relativa sezione trasversale; MFSNgp 43078.*

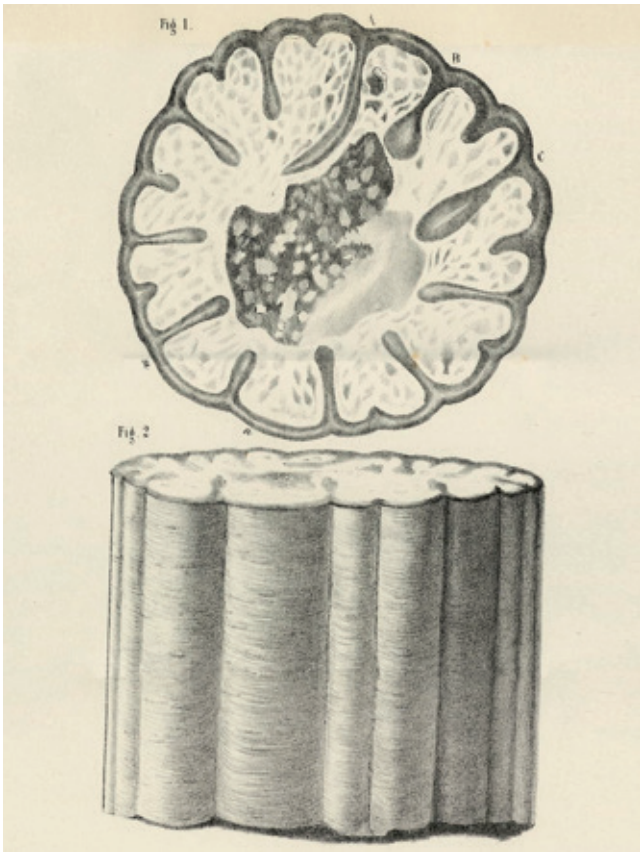

Fig. 15 - Drawing of *Pironaea polystyla* in the pubblication of Pirona (1868).
- *Il disegno di* Pironaea polystyla *nella pubblicazione di Pirona (1868).*

Sampling location	Rudists found in the olistoliths
1 - Plazzaris	*Durania* sp., *Biradiolites* sp., *Joufia reticulata*, *J. serbica*, *Caprinula boissyi*, *Caprina* sp., *Pironaea sp.*
2 - Plazzaris-Fese	*Bournonia* sp., *Vaccinites* sp.
3 - Montenars-Prato Martini	*Radiolites squamosus* ?, *R. gastaldianus, Medeella* sp.?, *Caprinula boissyi*
4 - Stella	*Radiolites squamosus*?, *Medeella* sp.?, *Vaccinites* sp.
5 - Clapon	*Durania*?, *D. arnaudi*, *Joufia reticulata*, *Caprina* sp., *Caprina adversa*?, *Sabinia* sp., Requienids, Radiolitids
6 - Rio Premalina	*Distefanella* sp., *Joufia serbica*, *Hippuritella* sp., *Plagioptychus* sp.
7 - Socret	*Sauvagesia* sp.
8 - Orvenco	*Vaccinites* sp.
9 - Ronc	*Sabinia anienis*
10 - Sammardenchia	*Medeella* sp.
11 - Crist	*Joufia serbica, J. milovanovici*

Tab. I - Rudists from olistoliths and blocks of the Montenars area.
- *Rudiste rinvenute negli olistoliti e nei grandi blocchi dell'area di Montenars.*

Family	Genera and species	Other localities	Age
Radiolitidae	*Biradiolites* sp.	Gorizia Karst, Trieste-Komen Plateau	Santonian-Campanian?
	Bournonia sp.	Trieste-Komen Plateau	Turonian-Senonian
	Distefanella sp.	Gorizia Karst, Sneznik (Slovenia)	Turonian-Senonian
	Durania arnaudi Choffat, 1891	Trieste-Komen Plateau	Campanian-Maastrichtian?
	Joufia serbica Milovanovic, 1956	Basovizza (Trieste), M. Nanos (Slo)	Campanian-Maastrichtian
	Joufia milanovanici (Šlisković, 1968)		Campanian-Maastrichtian
	Joufia reticulata Bohem, 1897	Mt. Jouf, T. Colvera (Pn)	Santonian
	Medeella zignana Pirona, 1869 designated Parona, 1924	Medea Hill, Gorizia Karst (Go), M. Nanos, Lipica (Slo)	Santonian
	Radiolites squamosus d'Orbigny, 1842		Santonian
	Radiolites gastaldianus Pirona, 1869	Medea Hill (Go)	Santonian
	Sauvagesia sp.	Medea Hill (Go)	Santonian
Hippuritidae	*Hippuritella* sp.	W-Friuli	
	Vaccinites sp.	W-Friuli	
Caprinulidae	*Caprinula* sp.	W-Friuli	
	Caprinula boissyi d'Orbigny, 1840	W-Friuli, Gorizia Karst	Upper Cenomanian
	Caprinula sharpei Choffat, 1885	W-Friuli	Cenomanian
	Caprina adversa d'Orbigny, 1840	Abruzzo	Upper Cenomanian
	Plagiopthychus sp.	W-Friuli, M. Nanos (Slo)	
	Sabinia aniensis Parona, 1908	Olistoliths Vigant (Ud), Anhovo (Slo)	Maastrichtian
	Sabinia sp.		
Requienidae	Requienids		

Tab. II - Rudists from Montenars olistoliths and their presence in adjacent areas.
- *Rudiste rinvenute negli olistoliti di Montenars e loro presenza nelle aree adiacenti.*

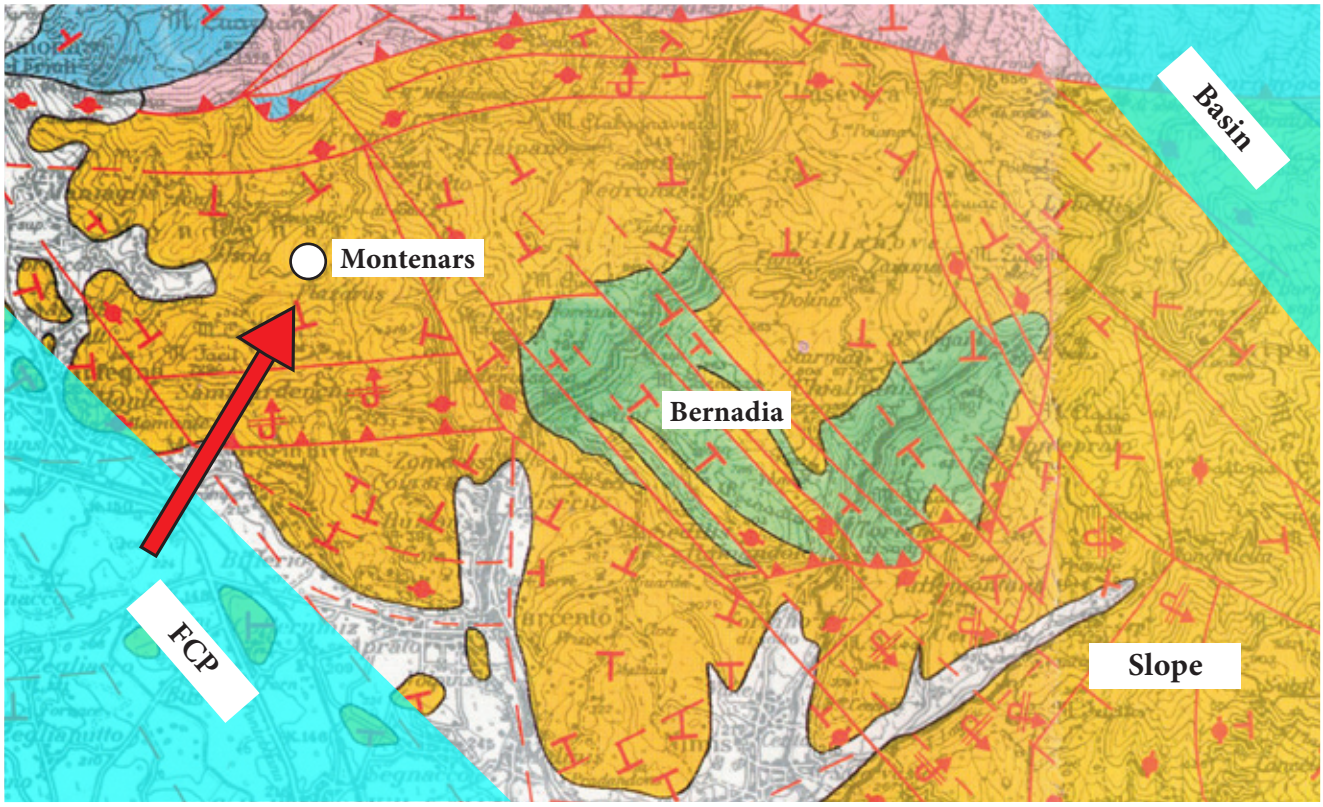

Fig. 16 - Palaeogeographic situation at Lowermost Paleocene and (red arrow) possible area of provenance for the Montenars olistoliths (base map from Venturini & Tunis 1989).
- *Situazione paleogeografica del Paleocene inferiore e (freccia rossa) possibile area di provenienza degli olistoliti di Montenars (mappa base da Venturini & Tunis 1989).*

the scholar who discovered it. A large number of *Pironaea* species has been proposed by different Authors in the past but Munujos et al. (2020), after the study of the external and internal characters of this rudist bivalve, made a careful revision of the genus in question reducing the number of the species to four, among these the historical *P. polystila*.

Examples of *Caprinula boissy*i (Fig. 14/F) have been recovered in Montenars and Plazzaris (Tab. I). This rudist until known in the Devetacchi succession (Tentor 2007) is characteristic of the Upper Cenomanian.

The specimen (Fig. 14/C) here assigned to *Radiolites gastaldianus* on the base of the published descriptions made by Pirona (1869) needs of a careful taxonomic revision. Infact, the taxonomic status and determinations of similar examples were historically debated with controversial synonimies proposed in different studies,

A number of rudists of Campanian or Maastrichtian age have also been recognized in the Vigant olistolith (genus *Sabinia*, Figs 10, 14/B), other rudists about coeval are known in the Carnian Prealps (Mt. Jouf, Colvera Brook), others are unknown in the outcropping successions of FCP (Tab. II). The collected rudists belong to the Upper Cenomanian, Turonian, Senonian and Maastrichtian and the pertaining carbonate platform facies to the mentioned stratigraphic intervals are lacking in the Mt. Bernadia and Judrio valley successions.

The location of some of the fossiliferous sites explored by Ruggero Tonello (Tab. I) is shown in Fig. 13.According to the geological section illustrated by Zanferrari et al. (2013), most of the sites seem to fall in the uppermost megabeds of the Flysch del Grivò. Is to note that the southernmost samples (site 10; Sammardenchia) seem to come from the lower tract of the overlying Marne e arenarie di Savorgnano (Zanferrari et al. 2013; previously Flysch di Cormons of this area).

Anyway, a number of stratigraphic, sedimentological and tectonic problems in the areas West and Northwest of Mt. Bernadia are unsolved, thus the difficulty in recognizing and mapping the megabeds in the zone in question. From this point of view an adequate study of the bio- and lithofacies of the blocks would support the creation of palaeogeographic maps and the recognition of provenances of the carbonate materials. However, some "liburnian" clasts suggest a southern source (Fig. 16) from innermost and apparently distal areas of the FCP (see also Borgo Vigant and Vernasso cases), because the Bernadia area drowned during the Campanian and the Flysch del Grivò onlapped the Mt. Bernadia slope during the Late Paleocene(?)-Early Eocene.

Thus, some problems arise: where was the edge of the FCP during the Maastrichtian and the Paleocene? How far was the Mt. Bernadia area from the platform edge? How many kilometers could the olitoliths have

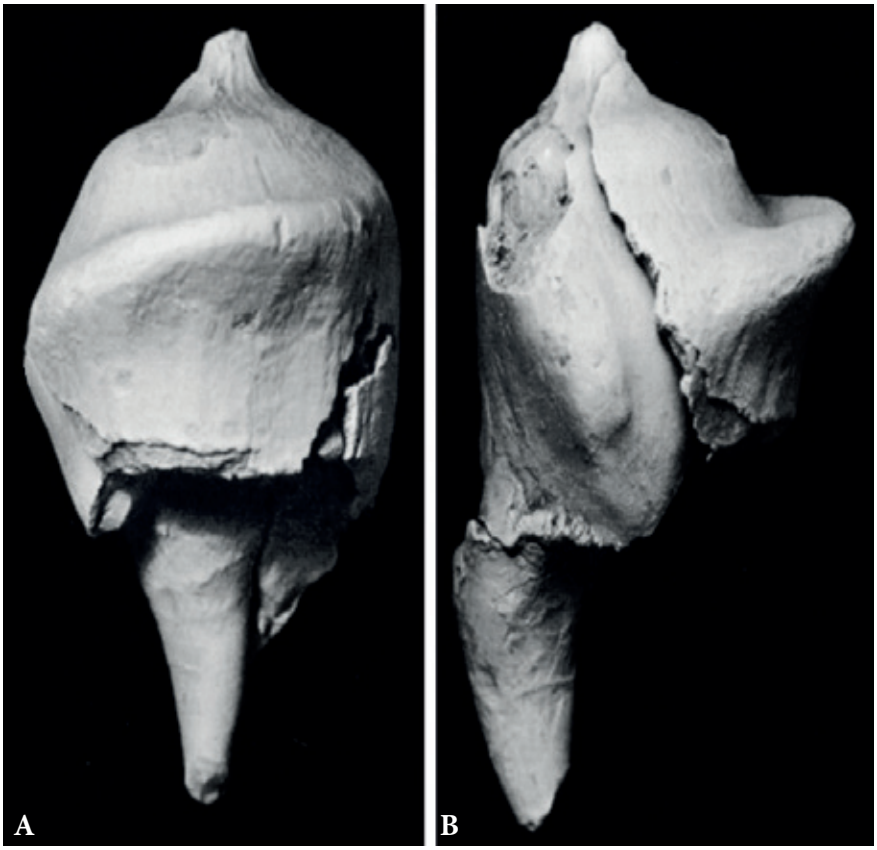

Fig. 17 - *Orthaulax dainellii*, Savazzi. Adult, dorsal (A) and right lateral (B) views; about 8 cm long. Holotype from Rio Zimor, near Tarcento (Udine). Museo di Geologia e Paleontologia, University of Firenze, n. IGF 2842E (from Savazzi 1989, cut out from fig. 1).
- Orthaulax dainellii, *Savazzi. Adulto, vista dorsale (A) e laterale destra (B) views; lunghezza circa 8 cm. Olotipo dal Rio Zimor presso Tarcento (Udine). Museo di Geologia e Paleontologia, Università di Firenze, n. IGF 2842E (da Savazzi 1989, ritaglio da fig. 1).*

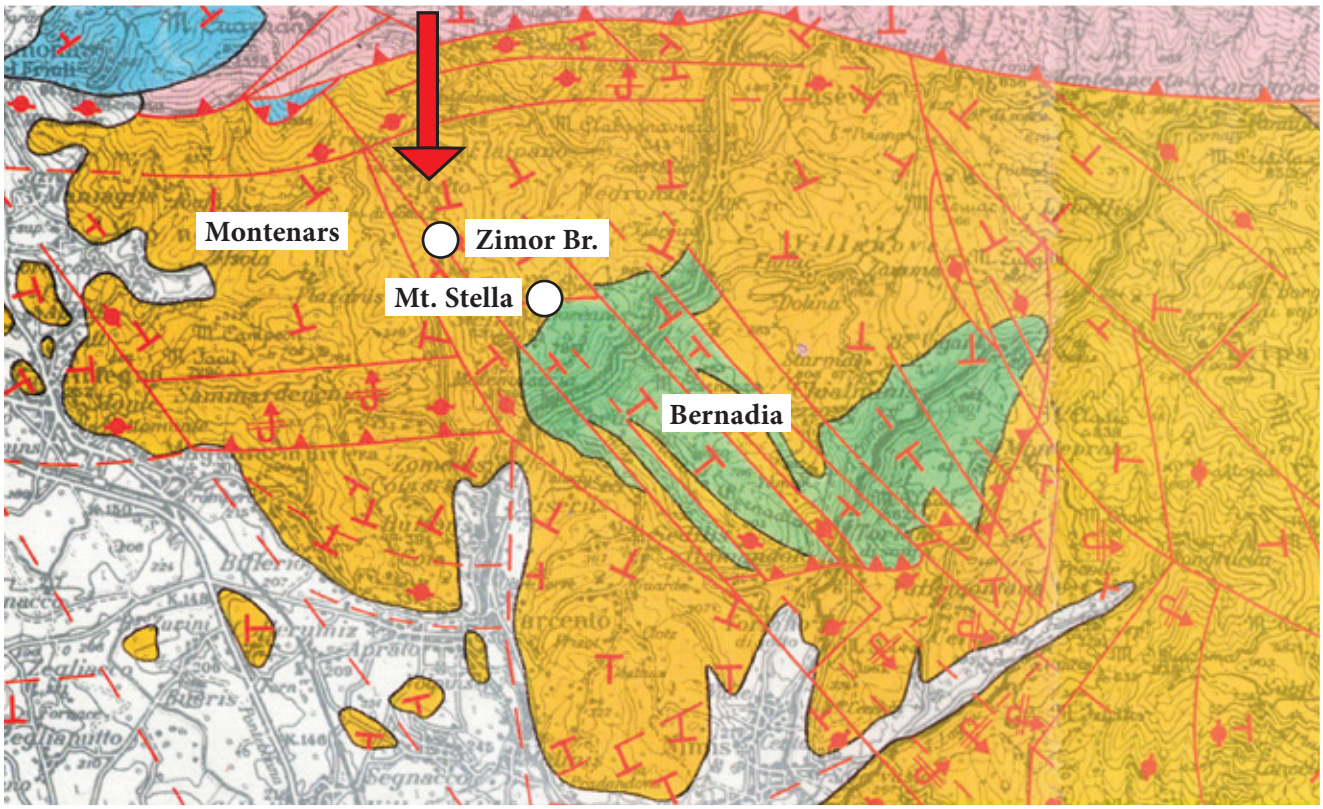

Fig. 18 - Outcrops of Zimor Brook and Mt. Stella olistostromes (white circles). Lower Eocene, Uppermost part of the Flysch del Grivò Fm. The arrow indicates the probable area of provenance for siliceous pebbles and mollusks (base map from Venturini & Tunis 1989).
- *Affioramenti degli olistostromi di Rio Zimor e Monte Stella (cerchi bianchi). Eocene inferiore, Parte superiore della Formazione del Flysch del Grivò. La freccia indica la probabile area di provenienza dei ciottoli silicei e dei molluschi (mappa base da Venturini & Tunis 1989).*

travelled? The outcropping Flysch del Grivò on the flanks of Mt. Bernadia pertains to the same basin of the FG detected by the Bernadia 1 well, under the Jurassic limestones of the Mt. Bernadia? The answers could represent solutions to significant sedimentological, palaeogeographic and paleotectonic problems.

The Zimor olistostrome

Olistostromes formed by coarse non-carbonate pebbles in an arenaceous-clayey matrix occour nn the uppermost part of the FG (Lower Eocene-upper part of the *M. subbotinae* biozone). These deposits outcrop in the area West of Mt. Bernadia, in particular near the Zimor Brook and Mt. Stella. Siliceous pebbles are frequent at Zimor Br., associated with calcareous clasts, mollusks, and rare Macroforaminifera; according to Savazzi (1989) "the sediment consists of dark grey marls containing abundant rounded pebbles and gravel, mostly consisting of black flint. Quartzite and metamorphic pebbles were also observed".

Some endemic species characterize these levels, such as the Strombidae *Orthaulax dainellii* (Savazzi, 1989) (Fig. 17). This form was previously determined as *Strombus tournoueri* Bayan by Dainelli (1915). *O. dainelli* is the oldest representative of *Orthaulax*, and the only species known from the Eocene. Outside the Julian Prealps (cfr www. Stromboidea.de) some specimens of *O. dainelli* are reported and figured, from Lower Lutetian of Albanello Quarry (Val Chiampo, Vicenza). Most of the specimens reported by Dainelli (1915) are stored in the collections of the Geological-Palaeontological Museum of the University of Florence; the holotype (Fig. 17) and the other specimens are fragmentary. Most probably better specimens are stored in MFSN or in other local museums. *Sycostoma bulbiforme* (Family Melongenidae) is another large gastropod reported by Dainelli (1915; figs 23 and 25 of table 56) from the localities of Zimor Br. and Mt. Stella. Until now, this species is known in Middle and Upper Eocene deposits (see Mikuž et al. 2013, *cum biblio*), but not in the classical fossiliferous sites of the Flysch di Cormons of the Julian Prealps and Collio area.

For this type of deposits, a northern origin can logically be hypothesized, clearly different from the carbonate megabeds of southern origin (Venturini & Tunis 1993). During the Lower Eocene, a drastic change in the coarse clastic inputs in the Julius Basin therefore occurred. Also in this case, as sometimes verified for megabeds, the fossiliferous content testifies to environments, facies and species no longer present or found in situ. The source may be represented by delta-marginal deposits located North of Mt. Bernadia (Fig. 18). The inclusions of not completely disorganized sandstone strips rule out long transport.

Delta-type deposits, which probably represent the sediments closing the northern margin of the basin, have been reported west of Monteaperta, near the Periadriatic overthrust (Pirini et al. 1986).

Research perspectives

The present contribution is based on many published and unpublished data, but it represents only a first step to be taken on a very long road. Future studies on the flysch units, on their stratigraphy and on their fossiliferous content will be able to provide answers from palaeontologic, palaeogegraphic and palaeotectonic points of view.

This way is and will be based on the museum collections, i.e. fossils and books, thus preserving our cultural heritage and the memory of the scholars who worked over.

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