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EXPERIMENTAL INVESTIGATION ON PALEOENVIRONMENTAL CHARACTERS OF VENETIA REGION USING ZOARIAL GROWTH-FORMS OF TERTIARY BRYOZOA

ABSTRACT - BRAGA GP. & FINOTTI F., 1999 - Experimental investigation on paleoenvironmental characters of Venetia region using zoarial growth-forms of Tertiary Bryozoa.

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Rich assemblages of bryozoans occur in many Tertiary outcrops in the Venetian and southern Trentine areas. The most important of these assemblages date from Late Eocene (Priabonian). These bryozoans lived along the margin of the Venetian platform. Sedimentological characters, faunal content, growth-form parameters, and inferences from the various species indicate that the depth range of the Venetia shelf would have been within the photic zone of the inner-outer interval, not more than 100 metres deep. The high bryozoan number of different species indicates that the sea was warm, temperate or subtropical, with well-oxygenated water of normal marine salinity. The paleoenvironmental characters of Venetian and southern Trentine areas were checked through the BRIO computer program presented by BIANCHI, BRAGA, FINOTTI & MANFREDI at the Shallow Tethys 3 Symposium - Sendai (1990). This computer program compared the similarity coefficient of samples located in the seven main Late Eocene bryozoan outcrops of the Venetia shelf. The calculation routine allows grouping similar samples without any contiguous link and analyzes in only one synthesis matrix the various matrices of basic bryozoan morphotypes, such as encrusting forms, rigid erect forms, and flexible forms. The obtained data confirm that an in-depth experimental investigation can better outline the geometry of Venetian carbonate platform margins of late Eocene.

KEY WORDS - Bryozoans, zoarial growth-forms, Tertiary, Q-mode, software BRIO.

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RIASSUNTO - BRAGA GP. & FINOTTI F., 1999 - Indagine sperimentale sulle caratteristiche paleoambientali dell'area Veneto-Trentina utilizzando le forme zoariali dei Briozoi terziari.

Sette tra le serie stratigrafiche eoceniche del Veneto e del Trentino meridionale, ricche in Briozoi e note in letteratura, sono situate lungo il margine della piattaforma carbonatica veneta. Dallo studio delle caratteristiche sedimentologiche, delle forme zoariali e delle indicazioni fornite dall'alta diversità biologica delle specie di briozoi si individua un ambiente subtropicale con acque calde, ben ossigenate e a salinità normale. Grazie al software BRIO, presentato da BIANCHI, BRAGA, FINOTTI & MANFREDI al Simposio Shallow Tethys 3 - Sendai (1990), si è potuto confrontare il «Coefficiente di similarità» di campioni localizzati in aree geograficamente separate e descritte nelle sette serie stratigrafiche che caratterizzano la piattaforma carbonatica veneta. La routine di calcolo ha consentito di associare e raggruppare campioni simili, senza nessun vincolo di contiguità, analizzando in un'unica matrice di sintesi le singole matrici relative alle forme zoariali e ai morfotipi di base dei Briozoi e alla tanatocenosi dei singoli sedimenti. L'analisi di questa matrice di sintesi ha confermato la validità dell'applicazione del metodo su scala regionale per poter descrivere con buona precisione la geometria del margine della piattaforma carbonatica veneta durante l'Eocene superiore.

PAROLE CHIAVE - Briozoi, Forme zoariali, Terziario, Q-mode, software BRIO.

In the Tertiary sequences of Veneto and South Trentino area there are many outcrops rich in bryozoan associations. The most important occurrences, both stratigraphically and paleogeographically significatives, date from Late Eocene (Priabonian). The living bryofaunas were located along the margin of Venetia shelf (fig. 1). According to sedimentological characters, faunal content, growth-form parameters, and inferences concerning the species in life, the depth range of the shelf would have been within the photic zone of the inner-outer interval, not more than 100 m deep. The sea was warm-temperate or subtropical, with well-oxygenated water of normal salinity, judging from the high number of different bryozoan species (GORDON & BRAGA, 1994) (see list of bryozoan in tab. I).

The stratigraphic layers of Late Eocene in Venetian and Southern Trentino (fig. 2), in the boundary sediments from Oligocene, are always rich in bryozoans, with different faunas and stratigraphically significant species. At Priabona (M.ti Lessini) and Brendola (M.ti Berici), these layers are called *Marne a Briozoi* and *Marne di Brendola*, and are well known right from last century especially by Austrian researchers as *Bryozoen Mergel* or *Bryozoen Schichten*. This important index layer, isochronous and found in all the examined sections, does not have the calcareous-marly lithology typical, for example, of sites like Priabona, but presents heteropies and different thicknesses, probably due to the paleoenvironmental situation of the Venetian-Trentino shelf margins.

Tab. I - List of Bryozoa

1 *Crisia elongata* Milne Edw. 1848
2 *Crisia haueri* Reuss 1848
3 *Crisia hoernesi* Reuss 1848
4 *Tubulipora foliacea* Reuss 1848
5 *Exidmonea atlantica* David, Mongereau et Pouyet.
6 *Exidmonea concava* (Reuss) 1848
7 *Exidmonea disticha* (Reuss) 1848
8 *Decurella toarensis* Mongereau et Braga 1967
9 *Exochoecia compressa* (Reuss) 1848
10 *Pleuronea reticulata* (Reuss) 1869
11 *Pleuronea pertusa* (Reuss) 1848
12 *Oncousoecia biloba* (Reuss) 1848
13 *Fascigera dimidiata* (Reuss) 1848
14 *Desmeplagioecia tenuis* (Reuss) 1869
15 *Filisparsa fallax* Canu & Bassler 1920
16 *Filisparsa orakeiensis* Stoliczka 1864
17 *Mecynoecia proboscidea* (Milne Edw.) 1835
18 *Mecynoecia pulchella* (Reuss) 1848
19 *Hornera asperula* Reuss 1869
20 *Hornera concatenata* Reuss 1869
21 *Hornera frondiculata* Auct.
22 *Hornera sulcosa* Reuss 1866
23 *Tervia serrata* (Reuss) 1869
24 *Reteporidea coronopus* Canu & Bassler 1922
25 *Reteporidea sparsa* (Reuss) 1864
26 *Heteropora subreticulata* (Reuss) 1869
27 *Lichenopora beirichi* Reuss 1851
28 *Lichenopora goldfussi* Reuss 1864
29 *Lichenopora grigonensis* Milne Edw. 1838
30 *Lichenopora radiata* (Savigny Aud.)
31 *Biflustra texturata* (Reuss) 1848
32 *Vincularia fragilis* Defrance 1820
33 *Vincularia subsymmetrica* Canu 1907
34 *Conopeum hookeri* J. Haime 1854
35 *Alderina subtilimargo* (Reuss) 1864
36 *Crassimarginatella macrostoma* (Reuss) 1848
37 *Stamenocella midwayanica* Canu & Bassler 1920
38 *Ramphonotus appendiculatus* (Reuss) 1848
39 *Semieschara subpyriformis* (D'Archiarc) 1846
40 *Vibracella trapezoidea (*Reuss) 1848
41 *Lunulites quadrata* (Reuss) 1848
42 *Calpensia gracilis* (Muenster) 1823
43 *Calpensia polysticha* (Reuss) 1848
44 *Steginoporella haidingeri* (Reuss) 1848
45 *Nellia tenella* Lamarck 1816
46 *Cellaria reussi* (d'Orbigny) 1851
47 *Chlidoniopsis vindobonensis* (Reuss) 1848
48 *Scrupocellaria brendolensis* Waters 1891
49 *Scrupocellaria gracilis* Reuss 1869
50 *Scrupocellaria montecchiensis* Waters 1891
51 *Scrupocellaria watersi* Bizzarini e Braga 1999
52 *Cribrilaria crenatimargo* (Reuss) 1848
53 *Cribrilaria radiata* (Moll) 1803
54 *Hippopleurifera* (?) *schreibersi* (Reuss) 1848
55 *Escharina phymatopora* (Reuss) 1848
56 *Schizoporella bisulca* (Reuss) 1869
57 *Gigantopora duplicata* (Reuss) 1848
58 *Porina coronata* (Reuss) 1848
59 *Porina labrosa* (Reuss) 1848
60 *Hippoporina angistoma* (Reuss) 1848
61 *Hippoporina lyratostoma* (Reuss) 1866
62 *Hippoporina sparsipora* (Reuss) 1869
63 *Escharoides aliferus* (Reuss) 1869
64 *Escharoides coccineus* (Abildgaard) 1806
65 *Smittina regularis* (Reuss) 1866
66 *Margaretta cereoides* (Ellis e Sol.) 1786
67 *Margaretta filiformis* (Canu e& Bassler) 1929
68 *Houzeauina parallela* (Reuss) 1869
69 *Ochetosella jacksonica* Canu & Bassler 1920
70 *Bactridium hagenovi* Reuss 1848
71 *Porella denticulata* (Stoliczka) 1864
72 *Tubucella papillosa* (Reuss) 1848
73 *Reteporella simplex* (Busk) 1859
74 *Reteporella tamaninii* Antolini,Braga e Finotti 1980
75 *Reteporella tuberculata* (Reuss) 1869
76 *Sparsiporina elegans* (Reuss) 1848
77 *Adeonella minor* (Reuss) 1869
78 *Meniscopora nodulifera* (Reuss) 1869
79 *Meniscopora syringopora* (Reuss) 1848
80 *Caberoides continua*(Waters) 1891
81 *Ditaxipora pannonensis* Antolini, Braga e Finotti 1980
82 *Ditaxiporina sepetentrionalis* Waters 1891
83 *Adeonellopsis porina* Roemer 1863
84 *Adeonellopsis subteres* Roemer 1863
85 *Cellepora globularis* (Bronn) 1837
86 *Fedora bidentata* (Reuss) 1869
87 *Orbitulipora petiolus* Lonsdale 1850
88 *Stenosipora protecta* (Koschinski) 1885
89 *Stenosipora reussi* (Stoliczka) 1862
90 *Stenosipora simplex* Koschinski 1885
91 *Batopora multiradiata* Reuss 1869
92 *Batopora rosula* (Reuss) 1848
93 *Batopora stoliczkai* Reuss 1867
94 *Lacrimula perfecta* (Accordi) 1947

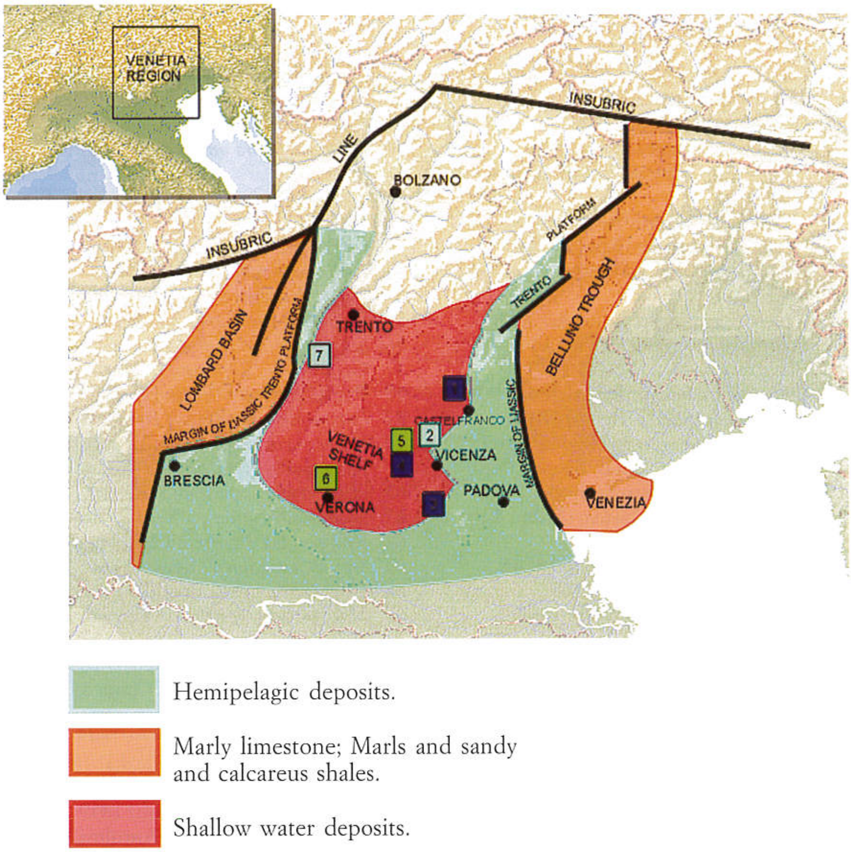

Fig. 1 - Location of the Tertiary bryozoan outcrops in the Venetia shelf, an important paleogeographic structure in the western Tethyan basin (from Bosellini 1989, modified). Explanation of symbols: 1: westward- marly limestones (Scaglia cinerea Formation); eastward- marls and sandy and calcareous shales (flysch facies); 2: shallow water deposits (shelf facies); 3: hemipelagic deposits.

The differencies between the western areas (Priabona and Verona), where limestones are prevalent, and the eastern margins of the shelf, where marly or silty-marly layers (Possagno-Crosara-Val di Lonte) are rather evident.

Software BRIO

The paleoenvironmental characters of this area has also been checked using BRIO program (see Bianchi, Braga, Finotti and Manfredi in Shallow Tethys 3,1990). This software compares the similarity coeffi-

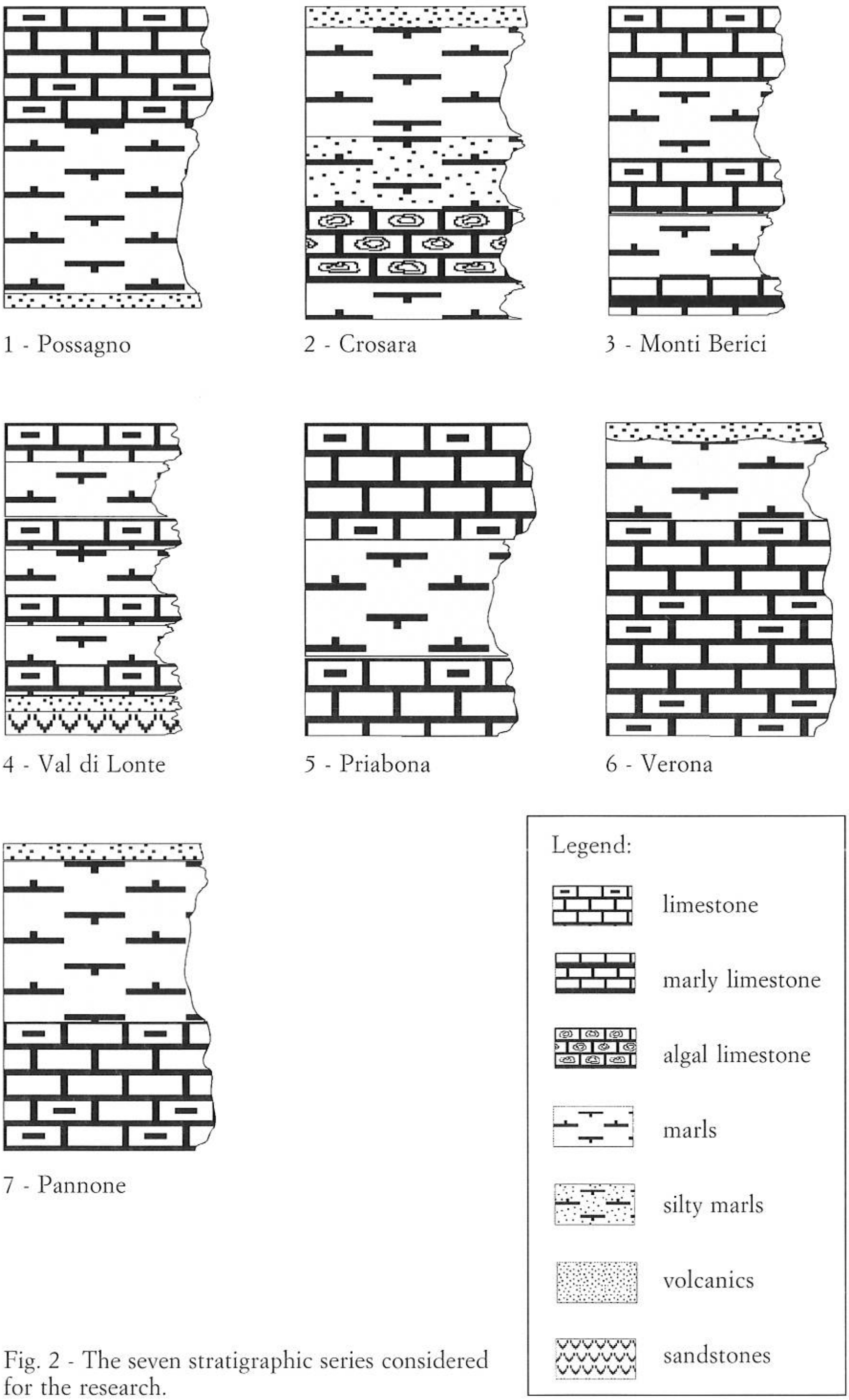

Fig. 2 - The seven stratigraphic series considered for the research.

cient of samples located in geographycally distinguished sites points and described in the above evidenced seven series of Venetia platform.

The used method for the analysis of data is partly based on the studies of Pielou (Q-mode analysis) and partly on articles published for the first conference of International Federation of Classification Societies (IFCS). During the analysis, BRIO shows the similarity matrices of the given data (fig.4) and for each one a numeric coefficient is calculated (Q/Qmax), which allows to verify whether the matrices have a regular or a casual order. Then clusters are visualised, obtained by maximising an homogeneity function through numerical methods. The research result is visualised with the similarity matrix divided in blocks. For every found block the program processes the similarity coefficient average of the clusters and the Q/Qmax. BRIO works even if data are not sequential. In this case, data are reordered so each sample is as similar as possible to the following one. Then the similarity matrix associated with the reordered data is visualised. This matrix is divided in clusters of homogeneous samples. BRIO works with six different similarity matrices associated to data sequences. According to their significance, different multiplicative factors are related to the matrices, in order to obtain a synthesising matrix of the general situation. This matrix is then divided in classes. For each class the barycenter of the cluster is calculated, for each of the six data types. The error is estimated by calculating the maximum distance of each unit of the cluster from its barycenter.

The calculation routine allows to group similar samples, without any link of sequential order, by analyzing in just one syntesis matrix the various matrixes of the basic morphotypes (encrusting forms, rigid erect forms, flexible forms and other forms) (fig. 3) of bryozoan associations and of zoarial growth forms. The syntesis matrix computed on the three available matrixes suggests three clusters (fig.5). We have therefore:

samples 1,3,4 Vinculariiforms 40%, Cellariiforms 17%, Lunulitiforms 13%, - encrusting forms 11%, rigid erect forms 56%, flexible forms 19%, other forms 12%;

samples 5,6 Vinculariiforms 63%, Membraniporiforms 16%, Eschariforms 11% - encrusting forms 16%, rigid erect forms 75%, flexible forms 4%, other forms 4%;

samples 7,2 Vinculariiforms 30%, Cellariiforms 17%, Reteporiforms 20%, Membraniporiforms 18%, Eschariforms 10% - encrusting forms 18%, rigid erect forms 61%, flexible forms 18%, other forms 2%. The error margin of the clusters is acceptable (always less than 7.5%).

In brief, the BRIO software selects three clusters where the main zoarial growth form is that of Vinculariiforms, but with an increase of

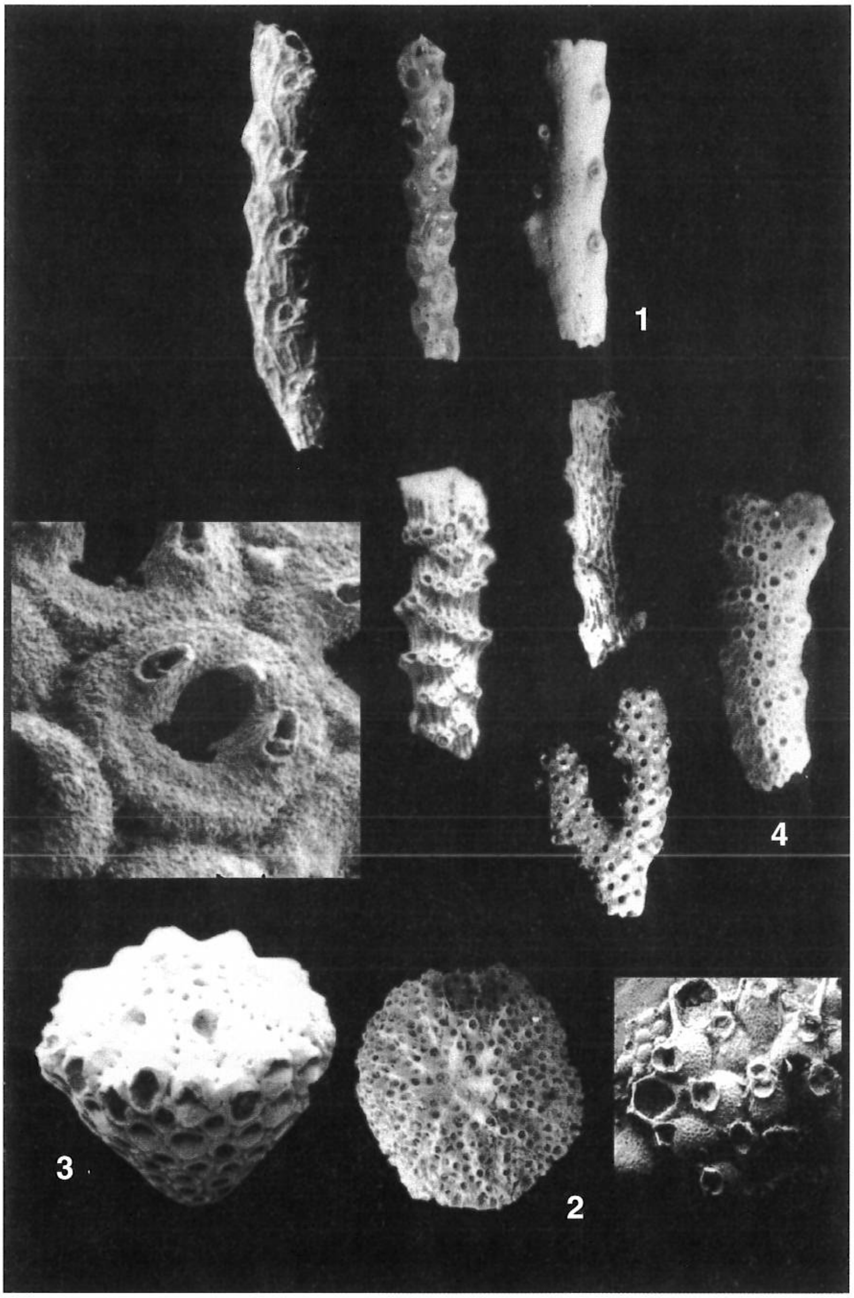

Fig. 3 - The four basic morphotypes: 1. flexible forms, 2. encrusting forms, 3. other forms e 4. rigid erect forms.

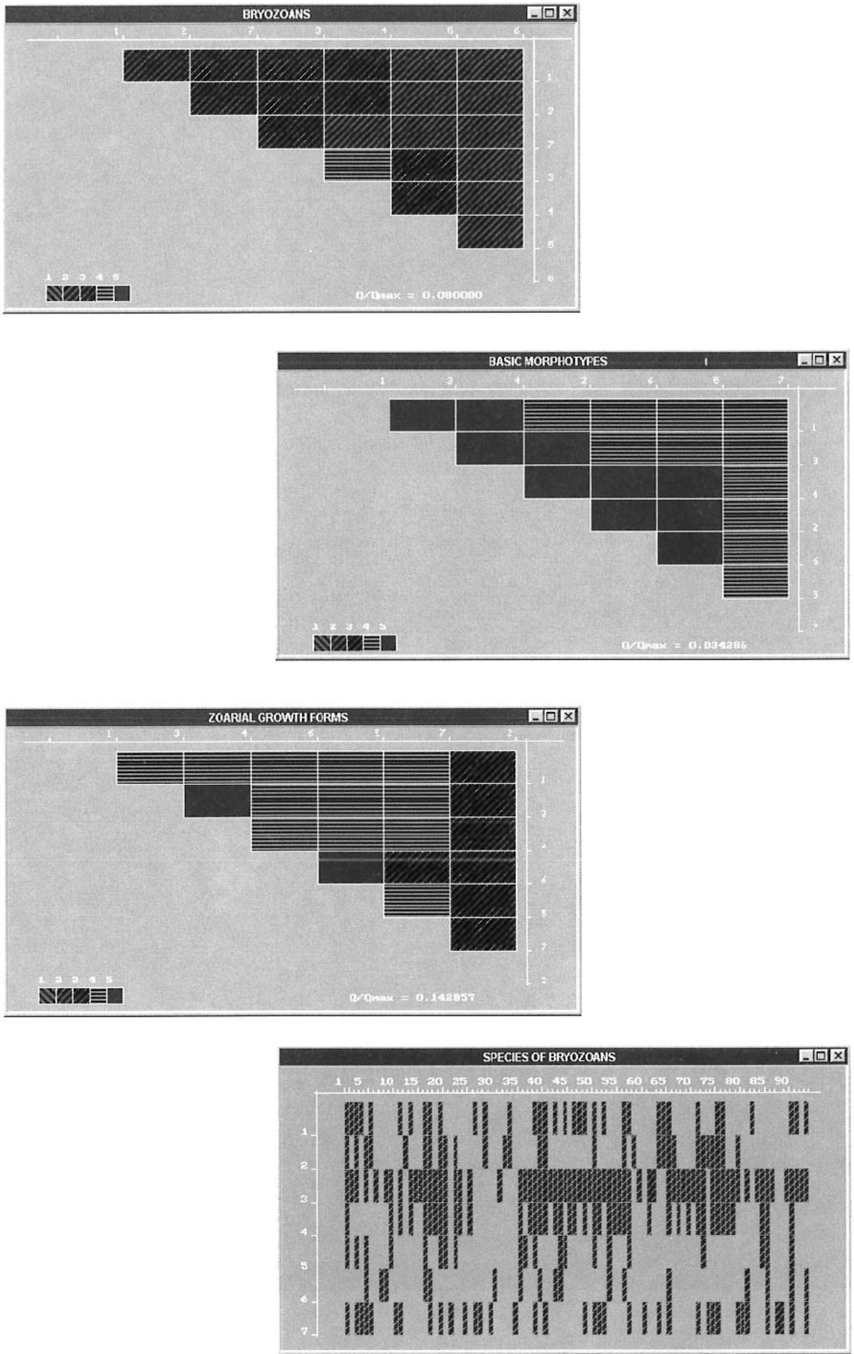

Fig. 4 - Examples of similarity matrices and of presence/absence of Bryozoans species.

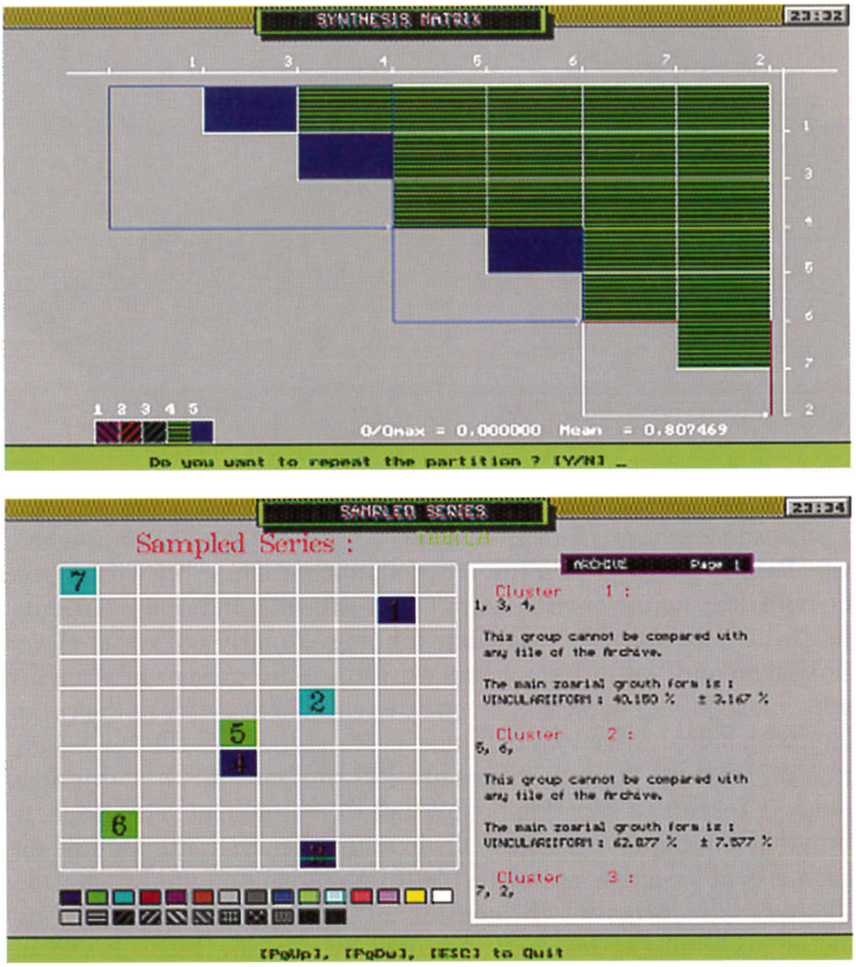

Fig. 5 - Synthesis matrix and cluster distribution.

the Cellariiforms and Membraniporiforms. These zoarial growth forms show a litoral and algal environment with a shallow waters.

Conclusions

Analysing both lithologies and sintex matrices, one can infer that biofacies are rather similar (calcareous algae, benthonic foraminifera, bivalves and gastropods) and typical of neritic areas, while matrices confirm lithological differences between western areas (Priabona and Verona) and eastern margins (Possagno-Crosara-Val di Lonte) (fig.6).

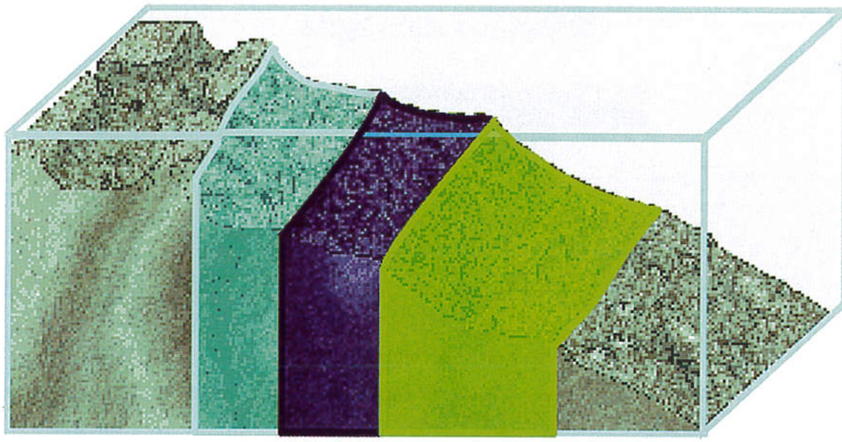

Fig. 6 - Bathymetric levels of the considered clusters.

Cluster 2 (samples 5-6) groups the two sites of Monti Lessini, where vinculariiform rigid erect forms are predominant. These bryozoans grow up with deep neritic environments (c.100 m), without bottom currents. In Cluster 1 (samples 1-3-4), where lithology is marly and rather clayey (Possagno and Val di Lonte) Vinculariiforms are present in a smaller percentage (40%), typical of a neritic environment closer to the coastline, with more terrigenous deposits. Very significant is Cluster 3 (samples 2-7), where Vinculariiforms are less present (30%), with a low, sandy (Crosara) or silty (Pannone) coastal environment. The data confirm that a in-depth experimentally investigation can better outline the geometry of Venetian carbonate platform margin on Late Eocene age. Therefore, by increasing the considered stratigraphical series and using all six similarity matrices identified by software BRIO it will be possible to precisely recreate the paleogeography of the Venetia shelf. The application (use) of this method on a regional scale is certainly of great scientific interest.

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REFERENCES

ANTOLINI P., BRAGA GP. & FINOTTI F. 1980 - I Briozoi dei dintorni di Rovereto: Monte Baldo Settentrionale e Valle di Gresta. *Pubb. Soc. Museo Civico Rovereto*, vol. 82, pagg. 102, figg. 80, tabb. 4.

BIANCHI M., BRAGA GP., FINOTTI F. & MANFREDI M. 1990 - Ruolo dei Briozoi nelle interpretazioni paleoambientali. *Atti 4° Simposio Ecologia, Paleoecologia*

Comunità Bentoniche - Sorrento 1-5 Novembre, Museo Regionale Scienze Naturali Torino: 21-33, figg. 8.

BIANCHI M., BRAGA GP., FINOTTI F. & MANFREDI M. 1991 - The Role of Bryozoans in Paleoenvironmental Deductions. *Saito Hoon Kai, 1991 (Proceedings of Shallow Tethys 3, Sendai,1990). Spec. pub.*, n. 3: 469-476, figg.5.

BOSELLINI A. 1989 - Dynamics of tethyan carbonate platforms. *SEPM* (Special pubbl.), 44: 1-11, figg. 13.

BRAGA GP. 1963 - I Briozoi del Terziario Veneto. Primo contributo. *Boll. soc. paleont. ital.*, Modena.

BRAGA GP. 1966 - Briozoi dell'Oligocene di Possagno (Trevigiano occidentale). II contributo alla conoscenza dei Briozoi del Terziario Veneto. *Boll. Soc. paleont. ital.*, Modena, 4 (2) (1965): 216-244, figg. 3, tavv. 28-30, tab. 1.

BRAGA GP. 1968 - Notizie preliminari su una fauna a Briozoi del Miocene inferiore del Trevigiano occidentale. *Giorn. di geol.*, Bologna. 35 (2): 95-106; fig. 1, tab. 1, tav. 1.

BRAGA GP. 1969 - Bryozoa from the «Marne rosse» of Spilecco (Lessini Mountains, Verona). *Atti Soc. it. sc. nat. e mus. civ. st. nat. Milano.* 108: 303-311; figg. 3.

BRAGA GP. 1975 - I Briozoi dell'Eocene di Possagno. *Abh. Schweiz. Pal. Basel.* 97: 141-148; figg. 2, tavv. 3.

BRAGA GP. 1979 - Tentativo di interpretazione del paleoambiente in una serie oligomiocenica di Follina (Trevigiano orientale) per mezzo delle forme zoariali dei Briozoi. *St. tr. sc. nat., Acta geol.*, 56: 125-138; figg. 2, tab. 1.

BRAGA GP., FINOTTI F. 1999 - Tertiary Bryozoa of the Venetia region. *Proceedings of the International Symposium on Shallow Tethys* ST5, 1-5 february, Poster Session (Chiang Mai, Thailand).

BRAGA GP., GHIURCA V. 1970 - Considerazioni sui rapporti esistenti fra le marne a Briozoi dell'Eocene superiore del Veneto (Italia Nord orientale) e della Transilvania (Romania). *Atti e Mem. Acc. Patavina sc. lett. arti; cl. sc. ff. mm. nn., Padova.* 82: 151-161; tabb. 2, tav. 1;

BRAGA GP., ZAGORSEK K., KAZMER M. 1996 - Comparison between Venetian and Western Carpathian late Eocene Bryozoan faunas. *Reports of Shallow Tethys 4 International Symposium Albrechtsberg (Austria)* 8-11 september 1994. *Annali Museo civico Rovereto, sez.: arch., st., sc. Nat., Rovereto, (Suppl.)* 11 (1995): 259-270.

FINOTTI F. 1984 - Significato paleoambientale di alcuni ritrovamenti di Briozoi nei terreni terziari del Monte Baldo Settentrionale. *Natura Alpina*, 35:21-29, figg.2, tab.1, tav.1.

GORDON D.P. & BRAGA Gp. 1994 - Bryozoa: Living and fossil species of the catenicellid subfamilies Ditaxiporinae Stach and Vasignyellinae nov. *Mem. mus. natn. hist. nat.,* Paris. 161: 55-85; figg. 14.

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