

Bollettino della Società Paleontologica Italiana	36 (1-2), 1997	ISSN 0375-7633	293-301	-	Parma, Dicembre 1997
--	----------------	----------------	---------	---	----------------------

Paleoecologic and biostratigraphic analysis of the Middle Pliocene land molluscan faunas from the R.D.B. quarry (Villafranca d'Asti, Piedmont, North-West Italy)

Antonella D. CIANGHEROTTI
Dipartimento di Scienze della Terra
Università "La Sapienza", Roma

KEY WORDS - Paleoecology, Biostratigraphy, Land molluscs, Early Villafranchian, Middle Pliocene, Northern Italy.

ABSTRACT - The section of the R.D.B. quarry, located near Villafranca d'Asti (Villafranchian type-area, Piedmont Basin) is the thickest outcrop (38 m) of the Pliocene S. Martino Unit and its deposits are rich in freshwater and land molluscs. The land molluscan faunas coming from the hydromorphous paleosoils sampled at different levels of the succession have been analysed in order to discover their paleoecologic and biostratigraphic significance.

In each assemblage, hygrophilous land pulmonates are very abundant and associated with some aquatic species, suggesting extremely damp, even swampy environmental conditions. Slight differences in composition and ecologic characteristics among the assemblages - in particular in the percentage of specimens of hygrophilous and aquatic species - could be related to periodic variations in the water table level in these soils. Paleoecological analysis results are in accordance with the fluvial-lacustrine environment of the deltaic plain proposed by sedimentological analyses (Basilici, 1994, 1996). The record of numerous forestal species shows that there was arboreal vegetation in this area. Some species are indicative of a temperate climate, in accordance with plant macrofossil and pollen analyses (Martinetto, 1995; Bertoldi, 1996a, 1996b).

The occurrence of a lot of species typical of the Early Villafranchian of the Piedmont Basin (Triversa Faunal Unit of the mammal biochronology) proves that the R.D.B. succession was deposited during the Middle Pliocene. The Pliocene age is confirmed by some taxa in common with the molluscan faunas from Pliocene sites in Central and Western Europe (Rhine and Rhone Valleys).

Some of the R.D.B. Pliocene land species have also been found in the Dunarobba Fossil Forest deposits (Tiber Basin, Umbria, Central Italy), so that it has been possible to ascribe them to the Pliocene in spite of the lack of vertebrate remains.

RIASSUNTO - [Analisi paleoecologica e biostratigrafica delle malacofaune terrestri del Pliocene medio della cava R.D.B. (Villafranca d'Asti, Piemonte, Italia nord-occidentale)] - La successione della cava R.D.B., sita nel bacino Piemontese presso Villafranca d'Asti e dunque nell'area-tipo del Villafranchiano, rappresenta il massimo affioramento (38 m) dell'Unità litostratigrafica pliocenica di S. Martino; i suoi depositi si sono rivelati ricchi di molluschi continentali acquatici e terrestri. Le malacofaune terrestri rinvenute in diversi livelli della successione all'interno dei paleosuoli idromorfi sono state analizzate allo scopo di trarne informazioni di carattere paleoecologico e biostratigrafico.

Tutte le associazioni sono caratterizzate da alte percentuali relative ai polmonati terrestri igrofili, ai quali si accompagnano sempre alcune specie acquatiche; tale composizione è indice di condizioni ambientali estremamente umide o addirittura palustri. Piccole differenze sono state in ogni caso riscontrate nella composizione e quindi nei caratteri ecologici delle associazioni esaminate - in particolare nella percentuale degli individui di specie igrofile ed acquatiche - e ciò dovrebbe essere imputabile a periodiche variazioni del livello della falda acquifera in questo tipo di suoli. Le faune analizzate sembrano inserirsi bene nell'ambiente deposizionale fluvio-lacustre di pianura deltizia ricostruito dalle analisi sedimentologiche (Basilici, 1994, 1996). Il ritrovamento di numerose specie terrestri caratteristiche di un ambiente forestale suggerisce la presenza di vegetazione arborea nell'area. Alcune specie risultano inoltre indicative di condizioni climatiche temperate, in accordo con i risultati delle analisi palinologiche e paleocarpologiche (Martinetto, 1995; Bertoldi, 1996a, 1996b).

La presenza di numerose specie tipiche del Villafranchiano inferiore del bacino Piemontese (Unità Faunistica di Triversa della biocronologia dei mammiferi) dimostra che la successione della cava R.D.B. è stata deposta nel corso del Pliocene medio. L'età pliocenica è confermata dal rinvenimento di alcuni taxa in comune con le malacofaune continentali plioceniche di diverse località dell'Europa centrale ed occidentale (bacini del Reno e del Rodano).

Alcuni polmonati terrestri pliocenici appartenenti alle associazioni della cava R.D.B. sono stati rinvenuti anche nei depositi della Foresta Fossile di Dunarobba (Bacino Tiberino, Umbria, Italia centrale) rendendo così possibile l'attribuzione di questi ultimi al Pliocene nonostante l'assenza di resti di vertebrati.

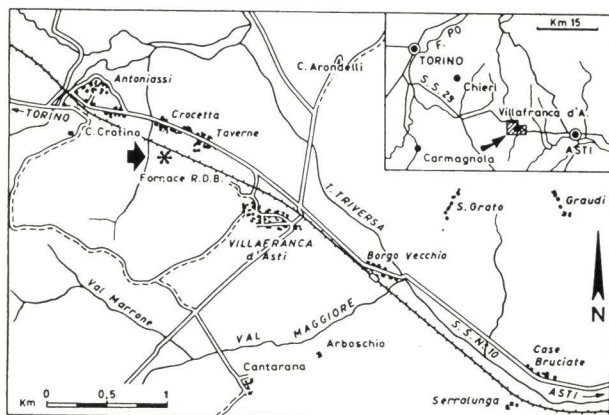
INTRODUCTION

Within the Piedmont Basin, which comprises

Langhe, Monferrato and Collina di Torino, the Villafranca d'Asti area is extremely important, especially as regards the continental stratigraphy;

in 1865, Pareto instituted the Villafranchian stage merely with reference to the successions of deposits outcropping here.

The section under investigation is the clay-quarry of the R.D.B. kiln, situated on the Villafranca outskirts, towards Turin (Text-fig. 1).



Text-fig. 1 - Location map of the R.D.B. quarry (from Francavilla *et al.*, 1970, with modifications).

The R.D.B. quarry (Text-fig. 2) is the thickest outcrop (38 metres) of the S. Martino Unit, which, according to the lithostratigraphic interpretation by Boano & Forno (1994; 1996), is the best exposed and most characteristic part of the Villafranchian type-succession; the continental deposits of this unit conformably overlie the lower part of the succession (Ferrere Unit), produced by coastal marine sedimentation.

Analysing in detail the R.D.B. quarry deposits, Basilici (1994; 1996) recognized four different and alternating lithofacies: "A" (delta canals), "B" (flooded areas), "C" (crevasses) and "D" (paleosoils); he also distinguished two different kinds of paleosoils: "D1" (hydromorphous) and "D2" (more mature).

The whole succession yielded interesting and abundant molluscan faunas: a lot of freshwater molluscs were recorded in the lithofacies "B"; a few also occur in the paleosoils of the lithofacies "D1", still characterized by land assemblages. The levels corresponding to the lithofacies "A", "C" and "D2" are sterile.

The purpose of this paper is to analyse the paleoecologic characteristics and the biostratigraphic significance of the land molluscan faunas recorded in the lithofacies "D1" paleosoils, sampled at different levels of the R.D.B. succession.

MATERIAL

Land molluscan faunas were found in five samples. Samples 1 and 2 - coming from the first two paleosoils at the base of the succession, (levels located at about 1.5 and 3.5 metres from the bottom) (Text-fig. 2) - were taken from the front of the quarry, as well as sample 5, taken from the paleosol whose top horizon is located not much above 35 m. In order to examine the middle part of the R.D.B. succession, a section placed in the corner between the front and the eastern side of the quarry was sampled in detail: in this section, differences in the lithology permitted the distinction of six levels (Ciangherotti, 1992-93), of which only the third (light grey massive clays) and the sixth (slightly laminated grey and brown clays intercalated by some peat layers) - here indicated as samples 3 and 4 respectively - yielded land molluscs.

ECOLOGIC CLASSES	
(from Lozek, 1964)	
1W	strictly forestal species
1W(f)	forestal species living among rocks and ground litter
2W(M)	species living mainly in woods, but also in mesophilous places and both damp and dry biotopes
2W(s)	species living in woods and scrubs, sometimes in open places (often in hedges and gardens)
4S	species living in dry and sunny places without arboreous vegetation
5O	species living in open places without arboreous vegetation
7M	mesophilous species which sometimes can live in damp or dry places
8H	hygrophilous species
9P	strongly hygrophilous species living in marshes or in similar very damp to wet places, generally very close to the water
10	aquatic species which can live in different biotopes or whose habitat can't be determined
10FPpQ	aquatic species living in moving waters, periodic marshes or springs
10P	aquatic species living in marshes and in shallow waters rich in vegetation
10S	aquatic species living in still waters
10SF	aquatic species living in still or moving waters
10SPPp	aquatic species living either in still waters or in marshes and periodic marshes
*	extinct species, whose habitat can't be determined
**	molluscs whose family has been identified, but whose genus and species can't be determined, so that there are not enough informations about their habitat
!	species indicative of warm-damp climate conditions
!!	species characterizing warm-damp climate conditions
+	loess species
(+)	species locally present in loess

Tab. 1 - List of the ecologic classes mentioned and their explanation according to Lozek (1964).

PALEOECOLOGY

METHODS

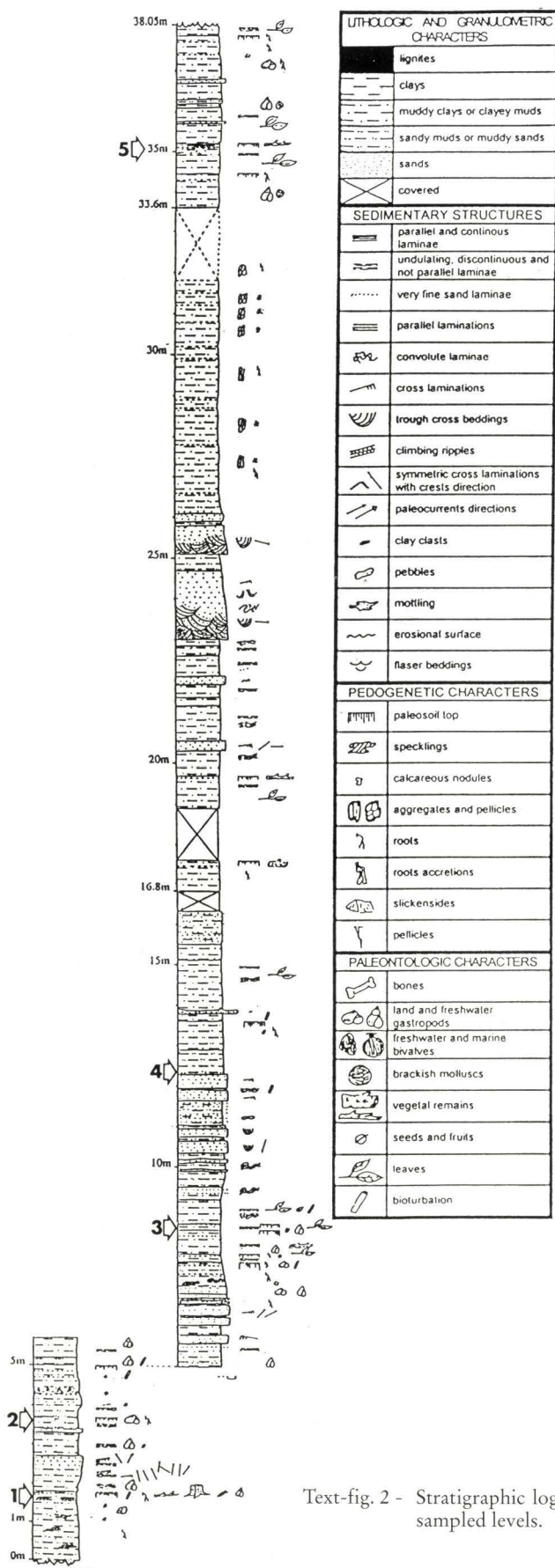
The percentage of the specimens of each species occurring in the sample unit recovered at each level was calculated. Then, following the method used by Lozek (1964), the species - according to their distinctive habitat - were placed in different "ecological classes", marked by the abbreviations explained in Tab. 1.

Considering the percentages of the ecologic classes in each sample, ecological spectra were obtained in histogram form (Text-figs. 3-6), which allow the reconstruction of the paleoenvironment where these sediments were deposited and where these molluscs lived.

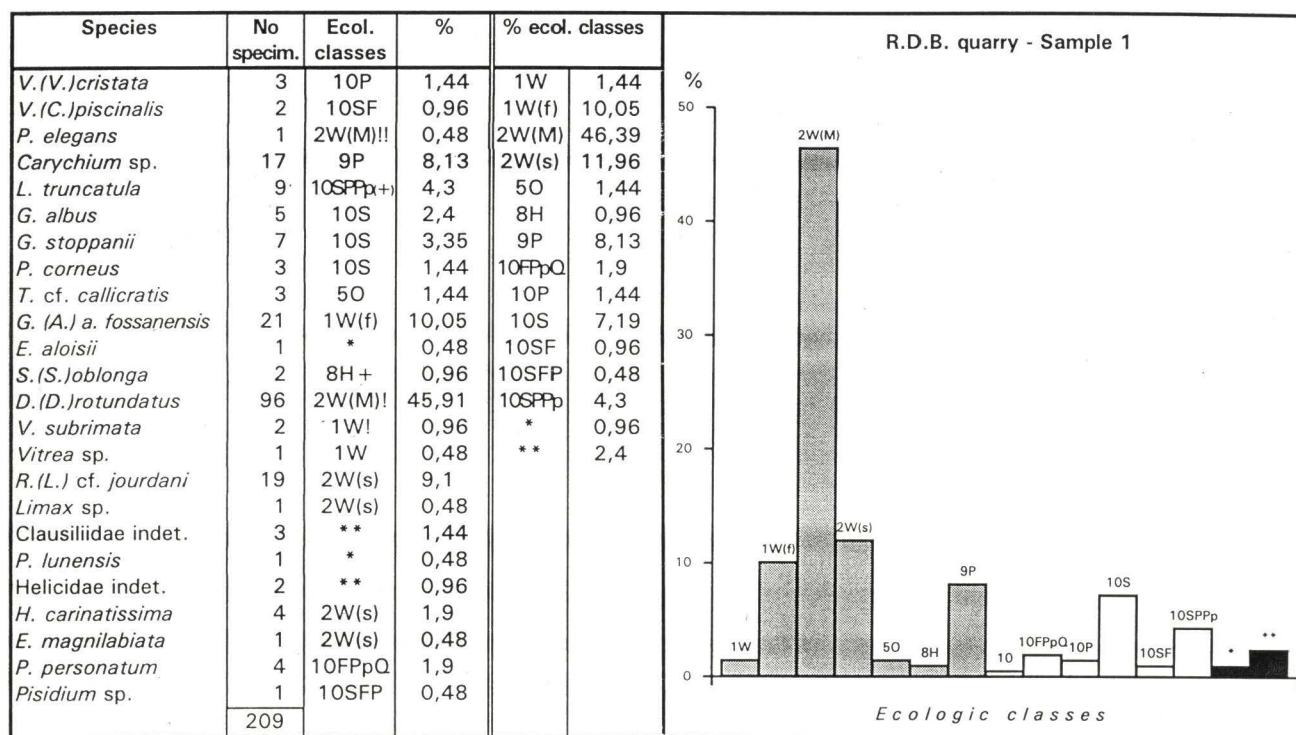
SAMPLE ANALYSIS

The highest percentage in the molluscan assemblage from sample 1 (Text-fig. 3) regards forestal species; they are represented by pulmonates living exclusively in woods (11.5%: *Gastrocopta (Albinula) acuminata fossanensis* (Sacco), *Vitrea (Vitrea) subrimata* (Reinhardt), *Vitrea* sp.), but also by mainly forestal species which can also colonize more open and less damp biotopes (about 58%), such as *Pomatias elegans* (Müller), *Discus (Discus) rotundatus* (Müller), *Limax* sp.. Hygrophilous and fen species (*Carychium* sp., *Succinea (Succinea) oblonga* Draparnaud) are much less frequent (9% in all). There are also a few specimens of *Truncatellina callicratis* (Scacchi), a species which prefers drier places without brushwood. Finally, a fair percentage (about 15%) of freshwater molluscs was recorded, mostly represented by pulmonate gastropods characteristic of still or swampy waters [*Lymnaea truncatula* (Müller), *Gyraulus albus* (Müller), *Gyraulus stoppanii* Sacco, *Planorbarius cornens* (Linneo)].

The spectrum reported for sample 2 (Text-fig. 4) shows the absolute predominance of extremely hygrophilous land pulmonates (about 73% of the whole assemblage), among which the genus *Carychium* prevails (more than 68%). The forestal gastropods are quite abundant (but less than in sample 1) and represented by a lot of species: *Renea* n. sp. (?), *G. (A.) acuminata fossanensis*, *Gastrocopta (Vertigopsis) dehmi* Schlickum &



Text-fig. 2 - Stratigraphic log of the R.D.B. quarry (from Basilici, 1994). The arrows indicate the sampled levels.



Text-fig. 3 - Paleoeologic features of the molluscan assemblage from sample 1. Species, number and percentage of specimens, ecological classes and their relative frequency are reported in the table. The graph represents the ecologic spectrum.

Strauch, *Acanthinula paronai* (Sacco), *D. (D.) rotundatus*, *V. (V.) subrimata*, *Retinella* (*Lyrodiscus*) cf. *jourdani* (Michaud), *Cochlodina* cf. *prolaminata* (Sacco), *Hygromia carinatissima* (Sacco), *Eobania magnilabiata* (Sacco). Molluscs which prefer more open and quite dry environments no longer occur and are replaced by more mesophilous elements (?*Punctum* sp.).

Sample 3 [Text-fig. 5) yielded only land pulmonates (except for one specimen of the aquatic prosobranch *Schuettemmericia lenoiri* (Schlickum)] among which exponents of the strongly hygrophilous genus *Carychium* are still dominant (nearly 70%); they are associated with a rather high percentage (about 25.6%) of more or less hygrophilous forestal species, i.e. *A. cf. paronai*, *D. (D.) rotundatus*, *Vitrea* sp. and *H. carinatissima*.

In sample 4 (Text-fig. 5) both hygrophilous and forestal species are less abundant (50% and 19% respectively). Conversely, a considerable percentage - more than 30% - of aquatic prosobranchs (*Valvata* (*Cincinna*) *piscinalis* (Müller), *Bithynia* sp.) and bivalves (*Pisidium* sp.), characteristic of slowly moving to stagnant waters, was recorded.

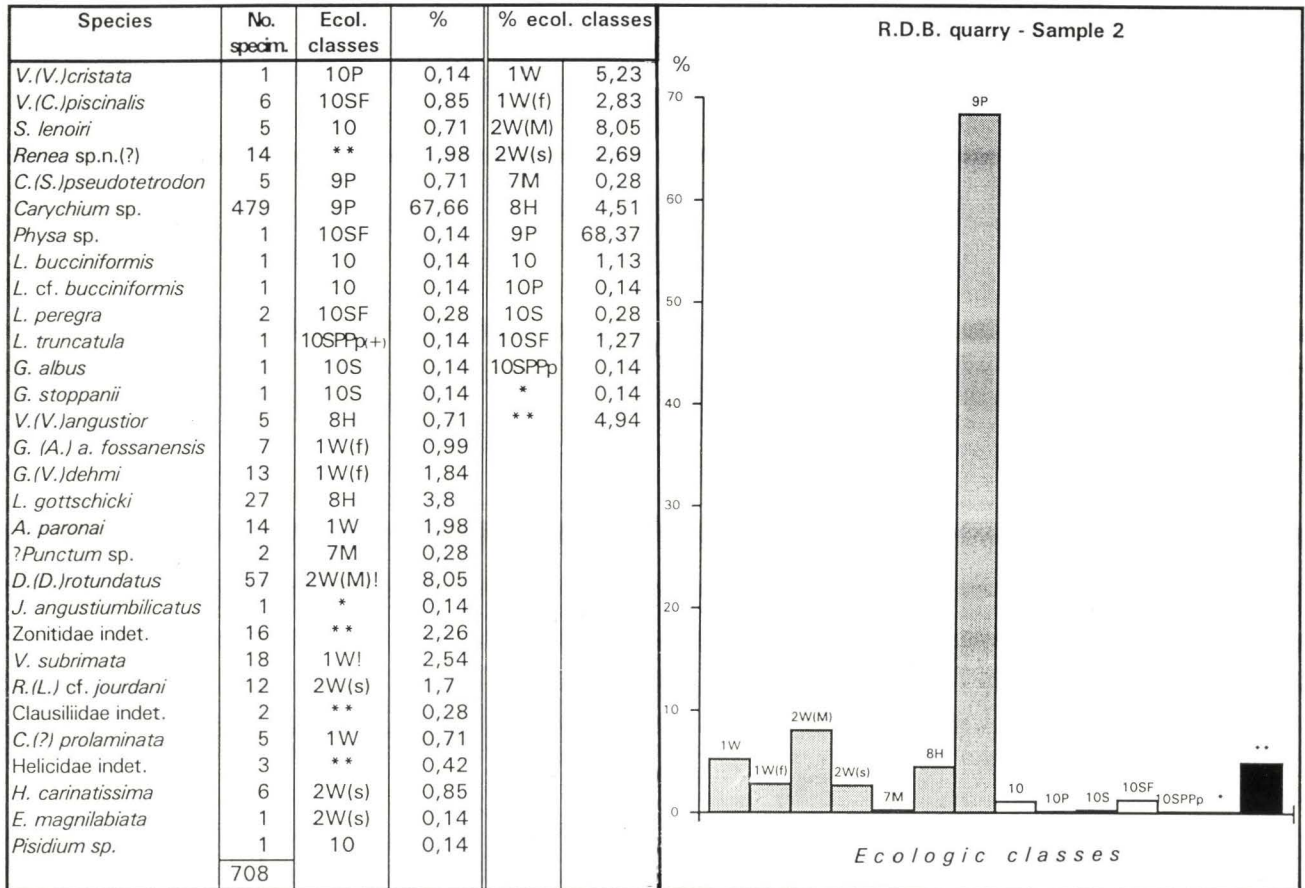
The molluscan content of the last sample (sam-

ple 5) (Text-fig. 6) shows a decrease in the percentage of specimens of land species, especially the forestal ones (about 7% in all), numerous but represented by a very low number of specimens. Strongly hygrophilous land pulmonates are still abundant (32%), but the strictly aquatic species prevail, since 49% of the assemblage consists of prosobranchs [*V. (C.) piscinalis*, *Valvata* (*Valvata*) *cristata* (Müller), *Bithynia* cf. *tentaculata* (Linneo), *Bithynia* sp., *S. lenoiri*].

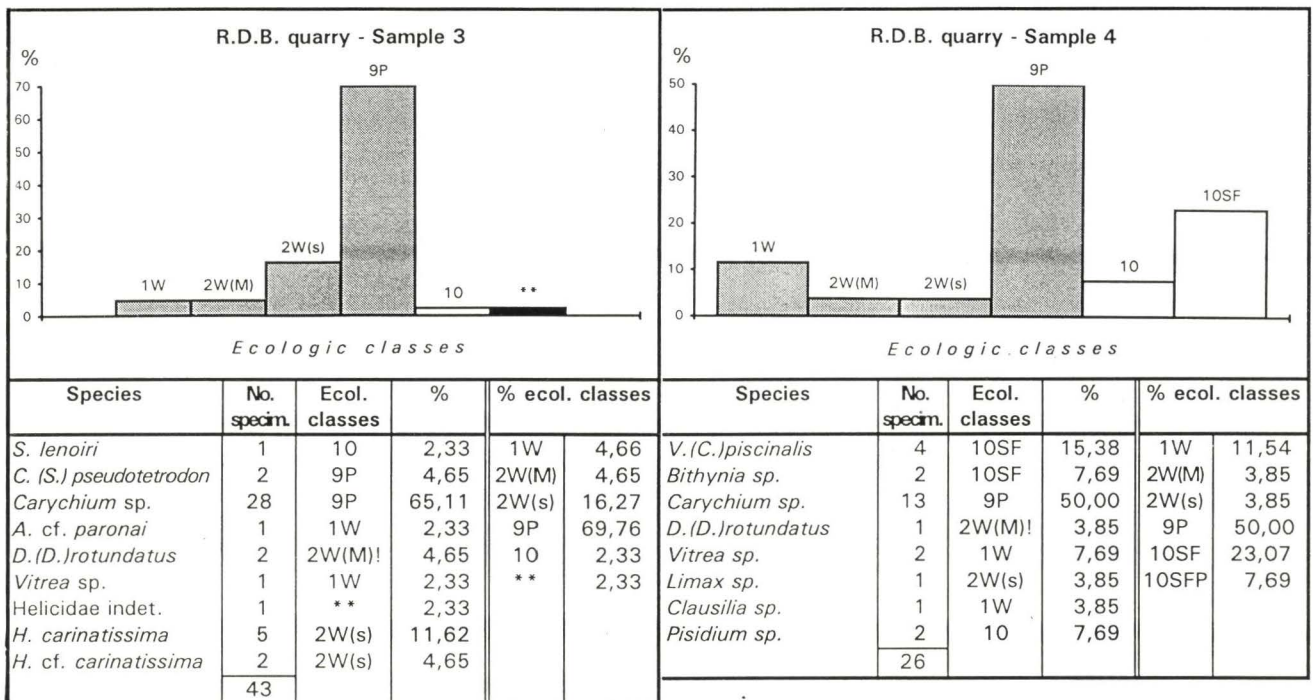
BIOSTRATIGRAPHIC DATA

The assemblages from the R.D.B. quarry include many extinct pulmonates, reported in the following list:

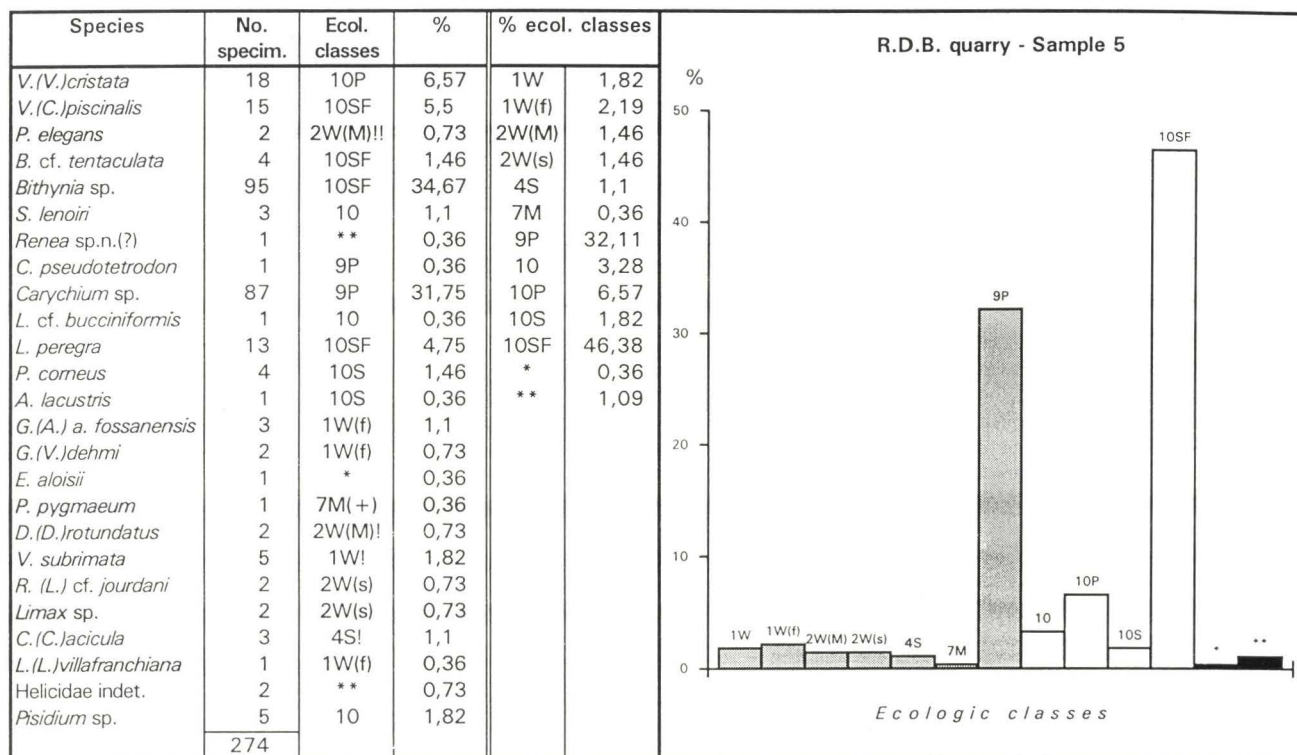
Carychium (*Saraphia*) *pseudotetrodon* Strauch
Gastrocopta (*Albinula*) *acuminata fossanensis* (Sacco)
Gastrocopta (*Vertigopsis*) *dehmi* Schlickum & Strauch
Leiostyla gottschicki Wenz
Acanthinula paronai (Sacco)
Eostrobilops aloisii Manganelli, Delle Cave & Giusti
Janulus angustiumbolicatus (Sacco)



Text-fig. 4 - Paleocologic features of the molluscan assemblage from sample 2. Species, number and percentage of specimens, ecologic classes and their relative frequency are reported in the table. The graph represents the ecologic spectrum.



Text-fig. 5 - Paleocologic features of the molluscan assemblages from samples 3 and 4. Species, number and percentage of specimens, ecologic classes and their relative frequency are reported in the table. The graphs represent the ecologic spectra.



Text-fig. 6 - Paleoecologic features of the molluscan assemblage from sample 5. Species, number and percentage of specimens, ecological classes and their relative frequency are reported in the table. The graph represents the ecological spectrum.

Retinella (*Lyrodiscus*) cf. *jourdani* (Michaud)
Cochlodina (?) *prolaminata* (Sacco)
Laminifera (*Laminiplicata*) *villafranchiana* (Sacco)
Palaeoglandina lunensis (D'Ancona)
Hygromia carinatissima (Sacco)
Eobania magnilabiata (Sacco)

Most of these species were instituted or mentioned by Sacco in his numerous papers at the end of the last century and have recently been reviewed by Esu (1982), Esu & Girotti (1974, 1991), Esu *et al.* (1993; in prep.), Ciangherotti *et al.* (1994, 1996); they are characteristic of the Early Villafranchian of the Piedmont Basin (Ciangherotti *et al.*, 1994, 1996), since they are part of the malacofauna found in the same deposits attributed by Azzaroli (1977) to the Triversa Faunal Unit (3 M.a. BP) on the basis of mammal remains.

Some of these and the other extinct species are in common with faunas from famous sites in Central and Western Europe basins (Rhine and Rhone Valleys) (Esu *et al.*, 1993; Ciangherotti *et al.*, 1994, 1996) (Tab. 2).

C. (S.) pseudotetrodon has been recorded in

the Late Pliocene of French sites in the Rhone basin (Celleneuve, Dép. Hérault and Cessey-sur-Tille, Dép. Côte d'Or) (Strauch, 1977), as well as *Hygromia carinatissima* (Sacco) from Celleneuve and Frontignan (Dép. Hérault) (Truc, 1971).

G. (A.) acuminata fossanensis has been found instead by Schlickum & Strauch (1979) in the Late Pliocene of Tagebau Frechen and Tagebau Fortuna (Rheinische Braunkohle, Germany).

G. (V.) dehmi is from the Late Pliocene of Frechen and Fortuna (Schlickum & Strauch, 1979) and from the Plio-Pleistocene of the Bresse basin (France) (Puisségur, 1984); this species, though in

	R.D.B. quarry	Rhine Basin	Rhone Basin
<i>C. (S.) pseudotetrodon</i>	◆		◆
<i>G. (A.) a. fossanensis</i>	◆	◆	
<i>G. (V.) dehmi</i>	◆	◆	◆
<i>L. gottschicki</i>	◆	◆	
<i>R. (L.) cf. jourdani</i>	◆		◆
<i>P. lunensis</i>	◆		?
<i>H. carinatissima</i>	◆		◆

Tab. 2 - Distribution of some extinct species in European Pliocene basins.

Italy previously recorded only in Pliocene sediments, has recently been discovered in the Early Pleistocene of the Tiber Basin (Umbria, Central Italy) and of the Steggio basin (Treviso, Venetian Prealps, North-East Italy) (unedited data).

L. gottschicki has been found in the Late Miocene of Steinheim am Aalbuch (Württemberg, Germany) (Wenz, 1923) and Hollabrunn (Austria) (Schütt, 1967).

P. lunensis is a Plio-Pleistocene species known in continental deposits of Central Italy (Umbria and Tuscany) (Esu & Girotti, 1991, 1993); according to De Stefani (1876-84) it should be present also in the Pliocene (?) of France, since some specimens found in Provence and attributed by Tournouer (1877) to *Glandina antiqua* Issel, would seem to belong to *P. lunensis*.

As regards our specimens of *Retinella*, they are very similar to *R. (Lyrodiscus) jourdani* (Michaud) as described and figured by Rousseau & Puisségur (1990); this species is known only at the Pliocene site of Hauterive (Dép. Drôme), since the material from Cessey-sur-Tille and T. Fortuna, studied by Schlickum & Strauch (1975) and Schlickum (1975) and classified as *R. (Riedeliella) jourdani*, has been attributed by Rousseau & Puisségur to *R. (Lyrodiscus) skertchlyi* Kerney.

Some extinct land species recorded in the R.D.B. sediments also occur in the Dunarobba Fossil Forest deposits (Tiber Basin, Umbria, Central Italy) (Ciangherotti *et al.*, 1994; Ambrosetti *et al.*, 1995; Ciangherotti *et al.*, 1996). These species, included in the malacological assemblage from the clays encrusting the fossil trunks, are reported in the following list:

Carychium (Saraphia) pseudotetrodon Strauch
Gastrocopta (Albinula) acuminata fossanensis (Sacco)

Gastrocopta (Vertigopsis) dehmi Schlickum & Strauch

Leiostyla gottschicki Wenz

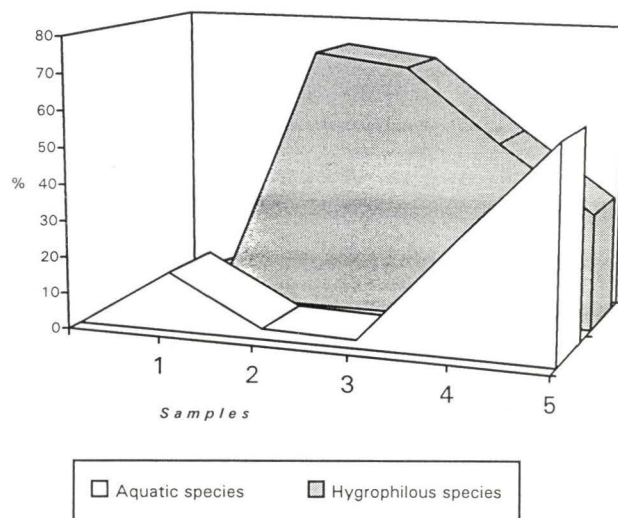
Eostrobilops aloisii Manganelli, Delle Cave & Giusti

Laminifera (Laminiplicata) villafranchiana (Sacco).

DISCUSSION AND CONCLUSIONS

The ecological characteristics of the molluscan assemblages examined are in accordance with the fluvial-lacustrine facies of deltaic plain of the deposits of the R.D.B. quarry (Basilici, 1994).

The occurrence in each sample of hygrophilous land pulmonates, very abundant and associated with some aquatic species, points to an extremely



Text-fig. 7 - Graph of the percentage variation of specimens of hygrophilous and aquatic species in the five samples.

damp, even swampy environment. As already mentioned, the sediments assigned to lithofacies "D1", from which all the samples were taken, correspond to hydromorphous paleosoils: these were soils in which the water table level was very close to the topographic surface, so that they were probably saturated with stagnant water for a large part of the year.

It is thought that differences among the assemblages in composition and characteristics - in particular in the percentage of specimens of hygrophilous and aquatic species (shown by the graph in Text-fig. 7) - could be related to periodic variations in the water table level, as also confirmed by sedimentologic analyses.

The record of numerous forestal species indicates that there was arboreal vegetation in this area.

Some species have also climatic significance: *P. elegans* (samples 1, 5), *D. (D.) rotundatus* (s. 1-5), *V. (V.) subrimata* (s. 1, 2, 5) and *Cecilioides (Cecilioides) acicula* (Müller) (s. 5) are generally recorded in sediments deposited during the Quaternary warm-damp spans (Lozek, 1964) and therefore indicate temperate conditions. According to the plant macrofossil analyses by Martinetto (1995) the R.D.B. vegetation can be classified as Stura "Florenkomplex", which corresponds to a "Mixed Mesophytic Forest" in transition with a "Mixed Evergreen Broad-Leaved Forest". This kind of vegetation gives indications for an average annual temperature of 13-14 °C and an average annual rainfall of 1000-3000 mm. Pollen analyses by Bertoldi (1996a, 1996b) con-

firm temperate climate conditions.

The biostratigraphic data point to a Middle Pliocene age for the R.D.B. molluscan fauna. Such indication is given by the mammal biochronology and is confirmed by the correlations with Pliocene sites in Central and Western Europe (Rhine and Rhone Valleys), as shown in Tab. 2. Among the species listed in the table, in fact, *C. (S.) pseudotrodon*, *G. (A.) acuminata fossanensis*, *R. (L.) cf. jourdani* and *H. carinatissima* can be considered as indicative of an exclusively Pliocene age.

Thanks to the findings of some species common to the Piedmont Pliocene molluscan fauna, it was also possible to assign the Dunarobba deposits to the Pliocene in spite of the lack of vertebrate remains, as already stated in Ambrosetti *et al.* (1995).

ACKNOWLEDGEMENTS

I am grateful to Prof. D. Esu and to Prof. O. Girotti for their precious suggestions and their help in the sampling.

REFERENCES

- AMBROSETTI, P., BASILICI, G., CIANGHEROTTI, A.D., CODIPIETRO, G., CORONA, E., ESU, D., GIROTTI, O., LO MONACO, A., MENEGHINI, M., PAGANELLI, A. & ROMAGNOLI, M., 1995, La Foresta Fossile di Dunarobba (Terni, Umbria, Italia centrale): contesto litostratigrafico, sedimentologico, palinologico, dendrocronologico e paleomacalologico: *Il Quaternario*, 8 (2): 465-508.
- AZZAROLI, A., 1977, The Villafranchian stage in Italy and the Plio-Pleistocene boundary: *Giorn. Geol. (ser. 2)*, 41 (1-2): 61-79.
- BASILICI, G., 1994, La successione-tipo villafranchiana - Sedimentologia. In *Revisione del Villafranchiano nell'area-tipo di Villafranca d'Asti*: Preprint. Conv. AIQUA-CNR "Il significato del Villafranchiano nella stratigrafia del Plio-Pleistocene", Peveragno (CN)-Villafranca (AT): 58-66; 71-81.
- , 1996, La successione-tipo villafranchiana - Sedimentologia. In Carraro, F. (ed.), *Revisione del Villafranchiano nell'area-tipo di Villafranca d'Asti*: *Il Quaternario*, 9 (1): 42-46; 50-56.
- BERTOLDI, R., 1996a, Palynostratigraphical outlines of Upper Neogene continental deposits in North-Western Italy: Abstract XIII Conv. S.P.I., Parma: 20-21.
- , 1996b, Pollini - Complesso inferiore. In Carraro, F. (ed.), *Revisione del Villafranchiano nell'area-tipo di Villafranca d'Asti*: *Il Quaternario*, 9 (1): 79-85.
- BOANO, P. & FORNO, M.G., 1994, La successione-tipo villafranchiana - Litostratigrafia. In *Revisione del Villafranchiano nell'area-tipo di Villafranca d'Asti*, Preprint. Conv. AIQUA-CNR "Il significato del Villafranchiano nella stratigrafia del Plio-Pleistocene", Peveragno (CN)-Villafranca (AT): 55-58; 66-71; 82-87.
- & —, 1996, La successione-tipo villafranchiana - Litostratigrafia. In Carraro, F. (ed.), *Revisione del Villafranchiano nell'area-tipo di Villafranca d'Asti*: *Il Quaternario*, 9 (1): 38-42; 46-50; 56-62.
- CIANGHEROTTI, A.D., 1992-93, Le malacofaune continentali plioceniche del Bacino di Villafranca d'Asti e del Bacino Tiberino. Unedited thesis, Univ. of Rome "La Sapienza": 1-456.
- , ESU, D. & GIROTTI, O., 1994, Molluschi. In *Revisione del Villafranchiano nell'area-tipo di Villafranca d'Asti*: Preprint Conv. AIQUA "Il significato del Villafranchiano nella stratigrafia del Plio-Pleistocene", Peveragno (CN)-Villafranca (AT): 114-118.
- , — & —, 1996, La malacofauna continentale. In Carraro, F. (ed.), *Revisione del Villafranchiano nell'area-tipo di Villafranca d'Asti*: *Il Quaternario*, 9 (1): 93-94.
- DE STEFANI, C., 1876-1884, Molluschi continentali pliocenici d'Italia: Estr. Atti Soc. Tosc. Sci. Natur.: 1-196.
- ESU, D., 1982, Les mollusques continentaux du Villafranchien de l'Italie: indications biostratigraphiques et paleoclimatiques: Coll. Villafranchien Mediterr., 1: 71-82.
- & GIROTTI, O., 1974, La malacofauna continentale del Plio-Pleistocene dell'Italia centrale. I. Paleontologia: *Geologica Rom.*, 13: 203-294.
- & —, 1991, Late Pliocene and Pleistocene assemblages of continental molluscs in Italy: *Il Quaternario*, 4 (1a): 137-150.
- , — & KOTSAKIS T., 1993, Palaeobiogeographical observations on continental molluscs of Italy: *Scripta Geol., Spec. Issue*, 2: 101-119.
- FRANCAVILLA, F., BERTOLANI MARCHETTI, D. & TOMADIN, L., 1970, Ricerche stratigrafiche, sedimentologiche e palinologiche sul Villafranchiano tipo: *Giorn. Geol. (2)*, 36 (1968): 701-741.
- LOZEK, V., 1964, Quartärmollusken der Tschechoslowakei: *Rozpr. Ustr. Ust. Geol.*, 31: 1-370.
- MARTINETTO, E., 1995, Significato cronologico e paleoambientale dei macrofossili vegetali nell'inquadramento stratigrafico del "Villafranchiano" di alcuni settori del Piemonte (Italia NW): Doctorate thesis, Univ. of Turin: 1-149.
- PUISSÉGUR, J.J., 1984, Les faunes malacologiques plio-pléistocènes de la Bresse. Significations écologique, climatique et chronologique: *Géol. France*, 3: 281-302.
- ROUSSEAU, D.D. & PUISSÉGUR, J.J., 1990, Phylogénèse et biogéographie de *Retinella (Lyrodiscus)* Pilsbry (Gasteropoda: Zonitidae): *Géobios*, 23 (1): 57-70.
- SCHLICKUM, W.R., 1975, Die oberpliozäne Molluskenfauna von Cessey-sur-Tille (Département Côte d'Or): *Arch. Moll.*, 106 (1-3): 47-79.
- & STRAUCH, F., 1975, Zur Systematik westeuropäischer neogener Zonitidae: *Arch. Moll.*, 106 (1-3): 39-45.
- & —, 1979, Die Land- & Süßwassermollusken der pliozänen Deckschichten der rheinischen Braunkohle: *Abh. Senckenb. Naturf. Ges.*, 536: 1-144.
- SCHÜTT, H., 1967, Die Landschnecken der untersarmatischen Rissoen-Schichten von Hollabrunn, N.-Ö.: *Arch. Moll.*, 96: 199-222.
- STRAUCH, F., 1977, Die Entwicklung der europäischen Vertreter der Gattung *Carychium* O.F. Müller seit dem Miozän (Mollusca: Basommatophora): *Arch. Moll.*, 107 (1976): 149-193.

- TOURNOUËR, R., 1877, Notes paléontologiques sur quelques-uns des terrains tertiaires observés dans la Réunion extraordinaire de la Société géologique à Fréjus et à Nice: Bull. Soc. Géol. France, Ser. 3, 5: 841-856.
- TRUC, G., 1971, Heliceaea (Gastropoda) du Néogène du bassin rhodanien (France): Géobios, 4: 273-327.
- WENZ, W., 1923-30, Gastropoda extramarina tertiaria: Foss. Catal. I: 1-3387.

*(manuscript received November 30, 1996
accepted June 30, 1997)*

Antonella D. CIANGHEROTTI
Dipartimento di Scienze della Terra
Università "La Sapienza"
Piazzale A. Moro 5, 00185 Roma, Italy