Pathological development in response to environmental stress in some latest Permian foraminifers : preliminary report

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Pathological development in response to environmental stress in some latest Permian foraminifers: preliminary report

by

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Abstract.–JENNY C. and GUEX J., 2005. Pathological development in response to environmental stress in some latest Permian foraminifers: preliminary report. *Bull. Soc. vaud. Sc. nat. 89.3*: 171-184.
This paper presents some morphological variations observed in benthic foraminifers, particularly within the Permian biseriamminid family, that are thought be a response to an increase in environmental stress when compared to observations in extant benthic foraminifers. The development of aberrant forms is observed below the Permo-Triassic Boundary (PTB), confirming that the well-documented biological crisis at the PTB at the end of the Permian is gradual.

Keywords: Permo-Triassic Boundary (PTB), benthic foraminifers, Biseriamminids, stress, environment.

Résumé.–JENNY C. et GUEX J., 2005. Développement pathologique comme réponse à un stress environnemental chez les foraminifères du Permien terminal: note préliminaire. *Bull. Soc. vaud. Sc. nat. 89.3*: 171-184.
Des formes morphologiques aberrantes ont été observées chez un groupe de foraminifères benthiques du Permien téthysien, les Biseriamminidae.
Si l'on se réfère aux foraminifères benthiques actuels, les formes aberrantes analogues du Permien semblent conditionnées par le stress engendré par un environnement défavorable. Dans le cadre des recherches pour comprendre les causes de la grande crise biologique de la fin de l'Ere Primaire (Permo-Triassic Boundary, PTB), nos observations confirment que cette crise a été progressive et non brutale.

Mot clés: Limite Permien-Trias, foraminifères benthiques, Biseriamminidae, stress, environnement.

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Introduction

It is universally agreed that a major, severe crisis occurred within the biosphere at the end of the Paleozoic. A large percentage of marine species disappeared, but the causes of this crisis are not fully understood.

Some scientists have investigated the effects of an impact of extraterrestrial objects (e.g. Becker *et al.* 2001). Others think that the extinction of marine species was gradual (Beauchamp and Baud 2002). It is highly probable that there are several, different causes (e.g. Lethiers 1998).

Our study is based on observations of more than five thousand thin sections. This material has been collected in seven different areas of the Permian Tethys realm,

- Southern Alps (Italy and Slovenia),
- Greece (Hydra Island, Salamis Island, Aegina Island, Chios Island, Attica),
- The Taurus Belt (Turkey),
- Armenia,
- Iran (Alborz Mountains, Central Iran, Zagros Mountains),
- Oman,
- The Salt Range (Pakistan),
- South China (Meishan, Langfenya, Shangsi).

This collection regroups samples from stratigraphic sections or isolated samples, assigned in age from Cisuralian to Lopingian. It is held at the Geological Museum of Lausanne (Switzerland).

A micropaleontological inventory of this collection has been done (Jenny *et al.*, in preparation). Many results suggest that some foraminifers, especially taxa of the Biseriamminidae family, reacted strongly to an increase in environmental stress that strained marine life at the end of the Permian, prior to the Permo-Triassic Boundary (PTB).

This phenomenon, whereby aberrant morphologies develop, is clearly visible in some of the above-mentioned areas, in:

- Southern Alps,
- Tachkent section in the Taurus Belt,
- Dena Kuh section in the Zagros Mountains,
- Baid area in Oman,
- South China.

In Armenia, Taurus Belt and South China, other groups of foraminifers: the hemigordiopsids and the «paleonodosariids» develop dwarf forms just prior to the PTB, often in association with ostracods (Jenny *et al.*, in preparation).

Previous studies show that both benthic and planktic foraminifers are very sensitive to variations in their environment (e.g. Venec-Peyre 1981, Geslin and DEBENAY 1997, GESLIN *et al.* 2002). Such variations can fundamentally also have a strong impact on marine plankton (DIETER *et al.* 1999, RIESEBELL *et al.* 2000). This fact has been noticed at the end of the Maastrichtian (ABRAMOVITCH and KELLER 2003). In this instance stress due to strong warm conditions produces dwarf forms.

GESLIN *et al.* (2002) demonstrate that such extant benthic organisms react strongly to variations in their environment, such as changes in salinity and/or acidity of the water, by developing aberrant morphologies. During such episodes of stress, aberrant forms are more abundant (more than 1% of the whole population) than in a population which does not suffer stress.

Stress conditions on extant benthic foraminifer populations influence the:

- shape of the test,
- form and dimension of the proloculus and/or the first chamber
- thickness and microstructure of the wall
- coiling
- additional chamber(s)

This is illustrated in Figure 1.

Furthermore, RIESEBELL *et al.* (2000) showed that extant planktonic organisms (coccoliths) react to increasing CO_2 levels in the atmosphere by decreasing the calcification of their test. Coccoliths examined in this study present a very high ratio of incomplete or malformed individuals. Similar observations have been made on planktonic foraminiers (e.g. DIETER *et al.* 1999).

In the present study we shall present and describe similar types of aberrant morphological forms observed in Permian benthic foraminifers, especially in the Biserianmminidae family.

OBSERVATIONS ON LATE PERMIAN FORAMINIFERS

Since the end of the Middle Permian (Guadalupian), fusulinids (large benthic foraminifers), one of the main groups used for Permian biostratigraphy, present an evolution tending towards to a rapid decrease in the diversity of species and the number of individuals. Almost all large taxa with keriothecal wall structure disappeared at the end of the Guadalupian. Late Permian species of fusulinids present special morphologies as rhombic shape of test (Paleofusulina) or show irregularities in the coiling (Reichelina, Codonofusiella, Paradoxiella); some other taxa of this group present aberrant forms irespective of any biological crisis. Fusulinids disappeared at the end of the Permian time, prior to the Permo-Triassic Boundary. Their decline is however gradual.

Other groups of Permian benthic foraminifers (biseriamminids, hemigordiopsids, «paleonodosariids») also present a general evolutionary trend in which the involution of the test increases (JENNY 2002). For these groups, it is a normal evolutionary trend, widely but not globally observed.

Evolute coiled, planispiral forms show a classical evolutionary trend from evolute toward involute, as observed in ammonites (GUEX Cope, in GUEX 1992). In the small foraminifers, the biseriamminid evolutionary series: *Globivalvulina-Paraglobivalvulina-Paraglobivalvulinoides* (ALTINER 1999) is a representative example of this trend.

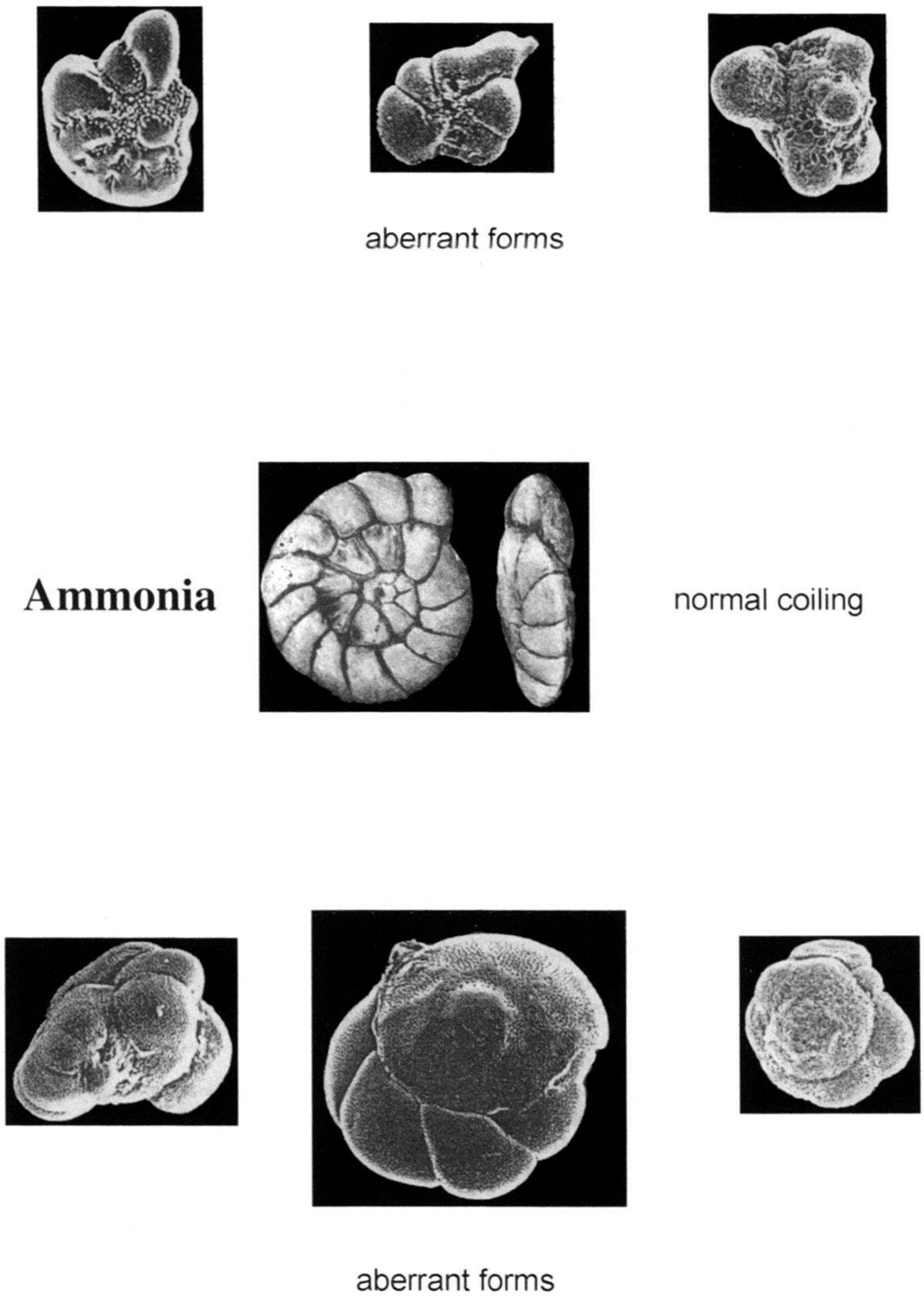


Figure 1.–Aberrant morphologies of Ammonia, extant benthic foraminifer. Adapted from GESLIN *et al.* (2002).

In the hemigordiopsid group, the tubular second chamber in *Hemigordius* becomes larger and engulfs more and more of the previous coil until complete involution, as seen in *Hemigordiopsis*.

Within the uniserial forms of the paleonodosarid group, the evolutionary trend shows successive overlapping chambers that are sometimes subdivided by vertical partitions as described in the genus *Colaniella*.

As these evolutionary tendencies can be observed in most Permian deposits of the Tethys realm where benthic foraminifers are present, these features are considered standard and therefore useful for Permian biostratigraphy, even when missing.

Within this framework, our study develops the idea that the great numbers of aberrant morphologies observed in the late Permian biseriamminid individuals are atypical and have another significance in addition to biostratigraphy.

In this family, the taxa *Globivlavulina* and *Paraglobivalvulina* developed many kinds of aberrant morphologies prior to the Permo-Triassic Boundary.

Normally, a micropaleontologist noting variations in well-known taxa suspects the presence of a possible new taxon.

Having observed so many variations in the morphology of *Globivlavulina* and/or *Paraglobivlalvulina,* appearing in one level of our stratigraphic study in the above-mentioned areas, prior to the PTB, without any stability of these morphologic variations, we decided to adopt another interpretation for these numerous variations.

We usually prefer not to split species too much so as to maintain greater value in our stratigraphic and paleogeographic work.

METHOD

Figures 2 and 3 present drawings of a selection of the different aberrant morphologies.

We chose this mode of illustration because we first collected observations after drawing a lot of individuals suspected of aberrant morphologies under microscopic study. We know it is easier to recognize details of all kinds of features with this method than with photographic pictures. It is a naturalistic approach.

We determined the aberrations comparing them with the normally accepted features of the concerned taxa.

Furthermore, this method is based on the one used by REICHEL (1945) and JENNY-DESHUSSES (1983, 1988).

In addition, we show some characteristic biofacies in four areas where aberrant forms of Permian forminifers are especially abundant.

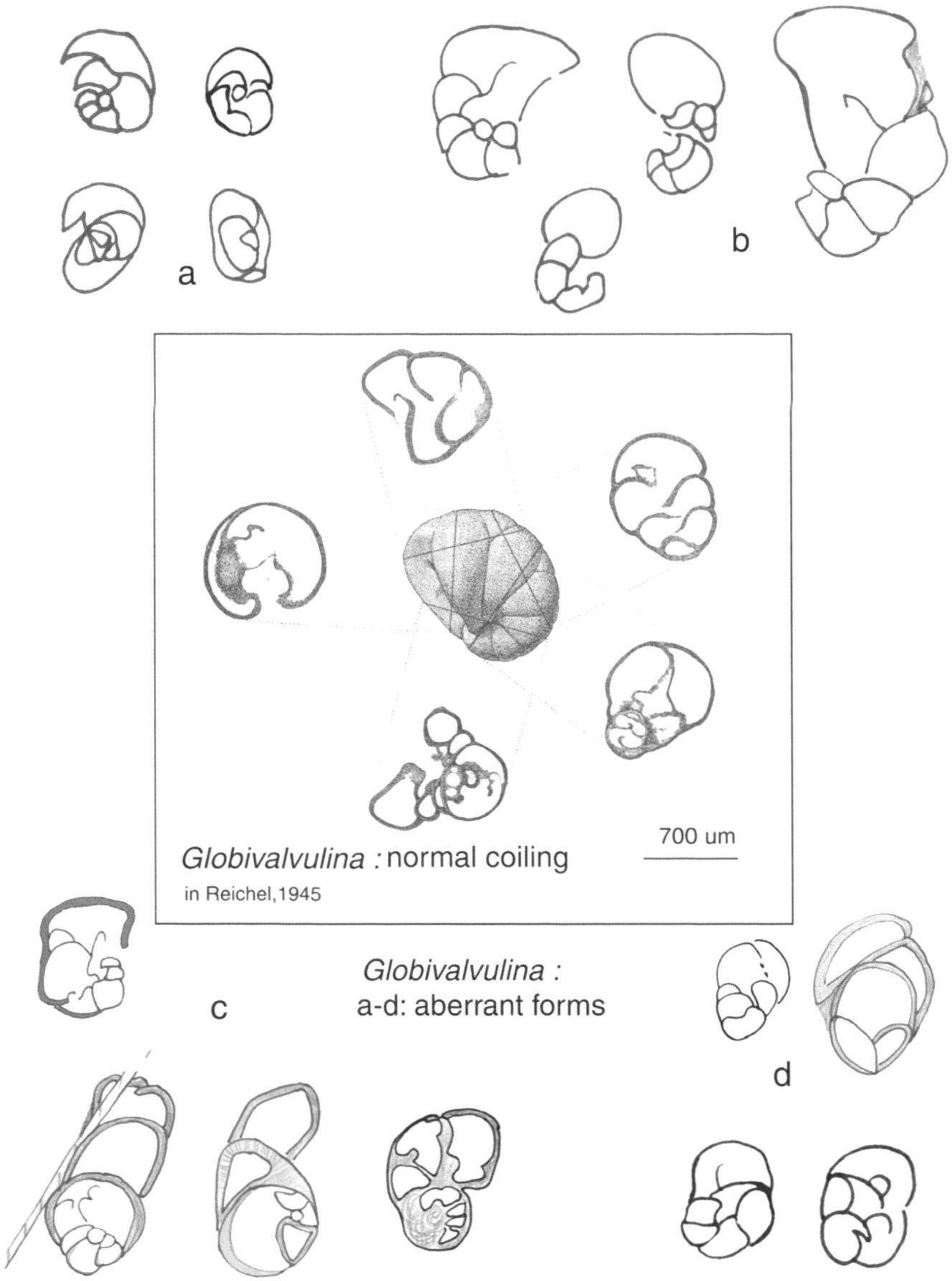


Figure 2.–Aberrant morphologies of Globivalvulina, Permian benthic foraminifer.

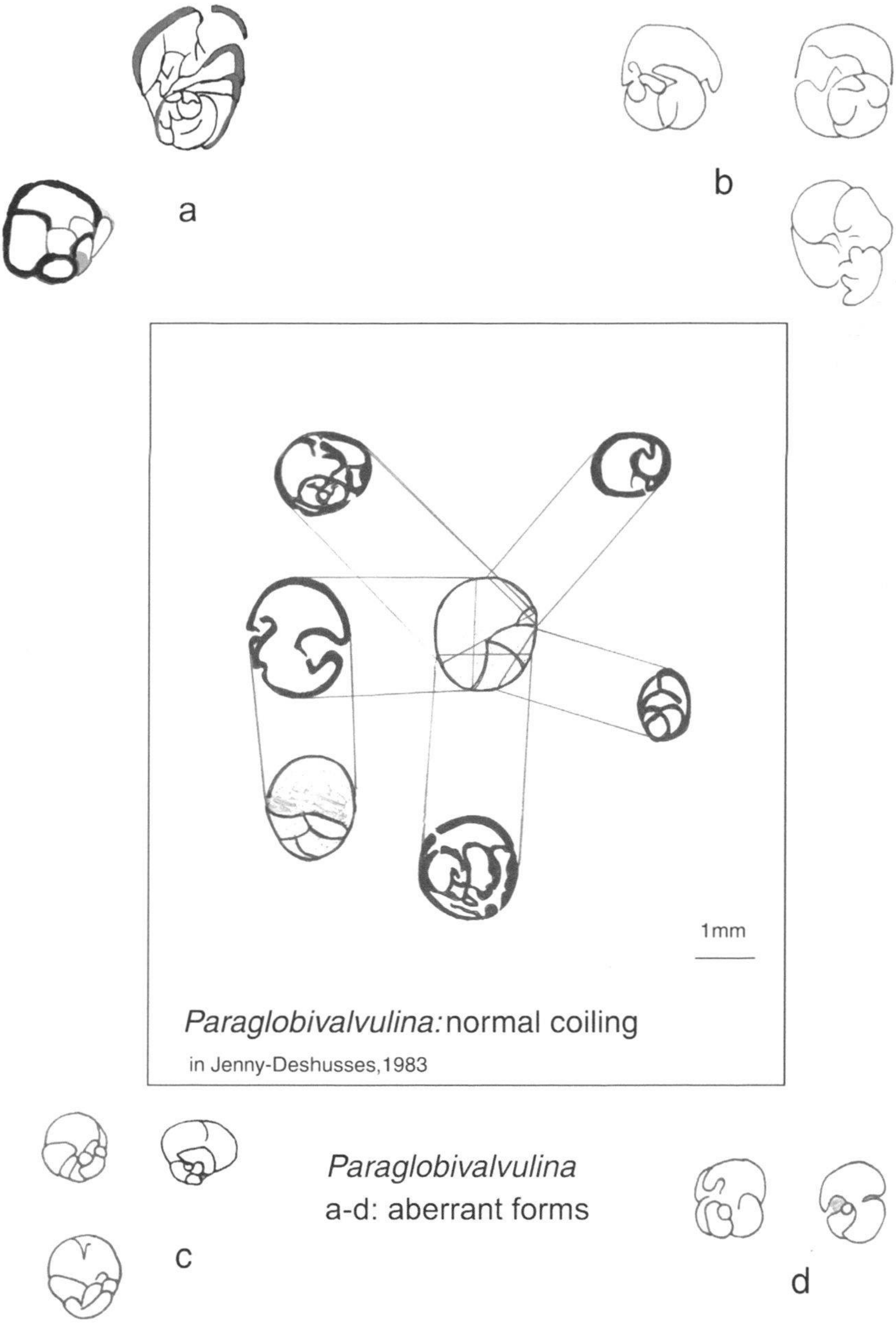


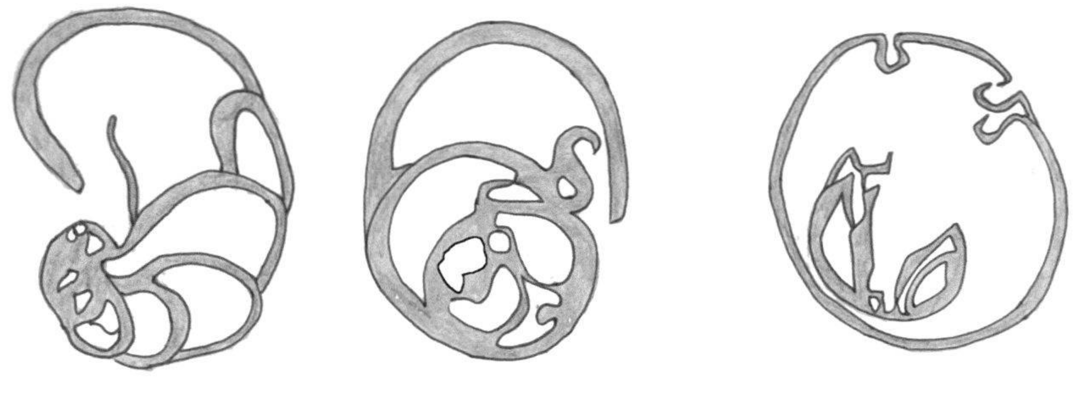
Figure 3.–Aberrant morphologies for Paraglobivalvulina, Late Permian foraminifer.

Summary of the main normal morphological features of Globivalvulina, Paraglobivalvulina and Paraglobivalvulinoides

Before describing aberrant morphologies (Fig. 2 and 3), we shall summarize the main regular features of these taxa (Tab. 1).

Table 1.–Main morphological features of Globivalvulina, Paraglobivalvulina and Paraglobivalvulinoides.

Globivalvulina	Paraglobivalvulina	Paraglobivalvulinoides
arrangement biserial coiled	arrangement biserial coiled	arrangement biserial? coiled
evolute	evolute last chamber or pair of chambers engulfed	involute
planispiral	planispiral, convolution = 1/3 of the high of the test	reduced convolution?
aperture covered by a straight or recurved valvular projection	aperture covered by strongly recurved tongue which forms a small apertural chamberlet in the last chamber	apertural chamberlet in all chambers
wall calcareous microgranular single layered	wall calcareous microgranular single layered	wall calcareous microgranular single layered



ABERRANT MORPHOLOGIES IN BISERIAMMINIDS

Within the Biseriamminidae family different types of aberrant morphologies are observed; some are thought to appear simultaneously (Fig. 2 and 3):

– decrease of the test dimension,
– wall thinning,
– loss of symmetry,
– coiling variations,
– change in the shape of the chamber (particularly the first one).

Occasionally individuals of the genus *Globivalvulina* exhibit features of the Early Permian species, recurring in Upper Permian.

GUEX (1992, 1993, 2001) has already proposed that highly stressed environments could lead to the reappearance of former species characteristics in ammonites and other groups such as Protists.

Such a phenomenon is observed in the *Globivalvulina- Paraglobivalvulina-Paraglobivalvulinoides* series, adding more weight to this proposal.

Within our material, aberrant forms of *Paradagmarita*, *Globivalvulina* and *Paraglobivalvulina*, as well as individuals presenting former features, coexist with individuals that develop characteristic features. Based on this, we can verify the age assignment of aberrant forms, by checking them with other associated taxa.

The morphology of the genera *Globivalvulina* and *Paraglobivalvulina* is well known, as both taxa have been studied in serial sections and/or oriented sections (REICHEL 1945, REITLINGER 1965, JENNY DESHUSSES 1983, 1988; ZANINETTI and ALTINER 1981, ZANINETTI and JENNY-DESHUSSES 1985). Therefore, aberrant forms are more distinguishable.

When identifying the genus *Paradagmarita* based on the author's description (Lys in LYS and MARCOUX 1978), we noted deviations where individuals do not exhibit the typical «bishop crook» axial section or lobed chambers.

Our material contains forms with an oval-shaped axial section showing pseudo-umbilical depression or other variable axial sections, unlike the characteristic lozenge-shaped axial section.

The described aberrant morphologies correspond to the variations developed in extant benthic foraminifers. Although we did not observe any modification of the first chamber, as known in extant benthic foraminifers, both cases exhibit anomalies in the:

– size
– wall thickness
– coiling
– chamber shape
– symmetry

In recent marine environments, it is relatively easy to measure water salinity and acidity but it is of course not possible to obtain the same data from fossil environments and to establish the influence of these variations on the development of aberrant morphologies. Nevertheless, we believe that the relationship between the two phenomema did exist in the past as it does today.

It is, however, possible to determine the relationship between isotopic variations (C, O) and the presence of aberrant forms. Work is underway on sections sampled in Turkey and Oman (RICHOZ and JENNY, work in progress).

GEOGRAPHICAL AND STRATIGRAPHICAL DISTRIBUTIONS

When inventorying foraminifers and calcareous algae in the above-described collection, we first observed aberrant forms in the biseriaminids group in the Southern Alps.

At that time we interpreted these forms as resulting from an anoxic environment due to confinement in the proximal part of a marine gulf.

Since then we have found such aberrant forms in other countries. These countries are: Turkey (the Southern Taurus Belt), the Oman Sultanat, Southern Iran (the Zagros Mountains) and the section of reference in South China (Meishan).

Biostratigraphical sections of Hydra Island (Greece), Armenia, or in the Alborz Mountains (Nothern Iran) and in the Salt Range (Pakistan) do not display such a high ratio of aberrant morphologies within the biseriamminid genera.

Table 2 summarizes the modified features for each taxa by region. This table is completed by Plate 1, showing some specimens of aberrant morphologies in their environment.

Furthermore, in Oman morphologic aberrations affect also *Globibalvulina vonderschmitti* REICHEL, even when the former recurrent species *Globivalvulina bulloides* (BRADY) and *Globivalvulina kantharensis* REICHEL are modified in the Taurus Belt.

In all regions studied, the stratigraphic position of aberrant forms is always situated below the Permo-Triassic Boundary.

In fact, there is usually a deposit series ranging from 0,5 to 90 meters thick between the deposits containing aberrant forms and exposures dated as Late Permian or Early Triassic.

This thickness is measured either from below the PTB assigned by conodonts, or above the last deposit in which assigned Permian faunal associations (foraminifers and algae) are observed.

Table 2.–Modified variations for each taxon by region.

Southern Alps	Globivalvulina	small size thinned wall chamber's shape
Taurus Belt	Globivalvulina Paraglobivalvulina Paradagmarita	small size thinned wall loss of symmetry chamber's shape former recurrent species
Zagros Mountains	Globivalvulina	small size thinned wall loss of symmetry
Oman Sultanat	Globivalvulina Paraglobivalvilina Paradagmarita	small size loss of symmetry chamber's shape former recurrent species
South China	Globivalvulina	small size thinned wall loss of symmetry

Conclusion

Late Permian is universally well known to be environmentally stressful and to be a time when marine communities were strongly disrupted. For a long time it has been thought that Permian benthic foraminifers could reveal a part of the Permian story.

In this scientific context, our study confirms that Permian benthic foraminifers are very sensitive to environmental variations and develop aberrant morphologies and/or dwarf form.

Globivalvulina, *Paraglobivalvulina* and *Paradagmarita,* belonging to the Biseriamminidae family, have for a long time been used as good indicators for Middle to Late Permian (Guadalupian to Lopingian) biostratigraphy in the Tethyan realm.

These taxa present a rapid morphological evolution, in addition to a large geographical distribution.

There is clear evidence that other groups of Permian foraminifers as Tetrataxiidae or Paleotextulariidae don't offer good enough features due to poor morphologic evolution to help us to understand what occurred during the Permian time and before the end of this system.

Furthermore, aberrant forms of the Biseriamminidae family described in the present study suggest that this fossil group responds directly to stress which disturbed marine environments at the end of the Permian. This group of microfossils illustrate this phenomenon very well.

The presence and stratigraphical position of aberrant forms, which occurred in the above-mentioned taxa, confirm that the great biological crisis signifying the end of the primary system began in the early Late Permian and gradually increased.

Very few benthic foraminifers survived Permo-Triassic extinction. Only dwarfed individuals representing a few other species (especially hemigordiopsids, «paleonodosarids») survived in the Late Permian, after disappearance of index large taxa of small foraminifers such as *Colaniella*, *Paraglobivalvulinoides*, *Hemigordiopsis*.

We insist on the importance of the above-mentioned inventory. This study allowed us to give evidence of these described aberrant morphologies in the Biseriamminidae family. In fact, these aberrations surprised us in a normal stratigraphic context prior to the PTB. Without studying these 5000 thin sections of samples collected in eight different areas, we would never have been able to pinpoint this phenomenon.

We don't know why the biseriamminids reacted so strongly to environmental stress. Maybe they were more prone to evolutionary trend and reacted rapidly to many kinds of ecological modifications.

The relationship between isotopic variations (C, O) and the presence of aberrant forms is part of Sylvain Richoz' thesis. Results will be published separately, but there is a very strong relationship.

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