

Micropaleontology from the STRATI 2013 perspective

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Summary

A description of the diversity of the micropaleontological world precedes a short description of its practical use in stratigraphy with two approaches, one for basinal areas and another for shallow-water (and continental) areas.

Keywords: Micropaleontology, biostratigraphy, event stratigraphy, sequence stratigraphy

There is not a single approach of micropaleontology and stratigraphy. One obvious justification of this assessment is that there is not one micropaleontology, but several (Haq & Boersma, 1978; Brasier, 1980; Bolli *et al.*, 1985; Bignot, 2001; Molina, 2002; Mathieu *et al.*, 2011).

A short review of micropaleontology and its techniques

Micropaleontology is the vast field of paleontology that deals with all small-sized (commonly less than 2 mm, down to a few μm , *i.e.*, nanofossils) fossil remains, which could be derived either from unicellular (prokaryotes and eukaryotes) or pluricellular organisms, but it also deals with giant eukaryotes, *i.e.*, uninucleate cells such as some large benthic foraminifers – Nummulites and Fusulinids, for instance – or Dasycladalean algae (with a body volume larger than 1 cm^3), as well as plurinucleate cells such as Bryopsidalean algae (the thalli of which can spray over several m^2 on the sea bottom). To summarize, the nature of the material studied is highly variable. For instance, on the basis of their chemical or mineralogical composition, microfossils can be subdivided into four general categories: 1) the calcareous microfossils, the more diverse category as it includes fish otoliths, ostracods, charophytes, red and green “calcareous algae”, foraminifers, *incertae sedis* like the gilianellids or the calcisphaerulids, calpionellids, calcareous dinoflagellate cysts, coccoliths, nannoconids and other nannoliths; 2) the siliceous microfossils with radiolarians, diatoms, siliceous dinoflagellate cysts and phytoliths; 3) the organic (including chitinoïd) microfossils like scolecodonts, chitinozoans, organic walls of foraminifers, pollen grains, spores, dinoflagellates, achritarchs, and cyanobacteria in Precambrian stromatolites; 4) the phosphateous microfossils with conodonts and rodent teeth, *etc.* Accordingly discrete techniques are required to investigate these materials. The study of organic microfossils, *i.e.*, palynological analyses, requires the embedding rock to

be dissolved by strong acids, the residue will then be mounted on a slide for observation on a photonic microscope or eventually some large specimens can be picked for observation on a scanning electron microscope. A similar destructive technique applies to condodonts because these phosphateous microfossils are found only in “hard” Paleozoic and Triassic rocks and to radiolarians because these siliceous microfossils are a common component of cherts. Other microfossils can be easily isolated from “soft” (unconsolidated) rocks by simple sieving and washing. But sometimes other techniques are required to improve surface appearance or extract planktonic foraminifers (see Moullade *et al.*, 2005, for instance), gilianellids (Odin & Lethiers, 2006), ostracods, charophyte gyrogonites, *etc.* Then this isolated material can be observed either in photonic or electronic microscopy. Large benthic foraminifers (fusulinids, nummulitids, orbitolinids, *etc.*) and most calcareous algae (dasycladales, sporeolithales, corallinales) cannot be identified at the specific level without knowledge of their internal structures and therefore they require oriented sections, which could be accessed through polished rock slabs, acetate peels or thin sections. In conclusion, the variety of the material (nature, dimensions, mounting techniques, observation tools) requires a fair degree of specialization for the micropaleontologists involved in these studies, which eventually are focused on limited intervals (one or two systems, even few stages) of the stratigraphic column.

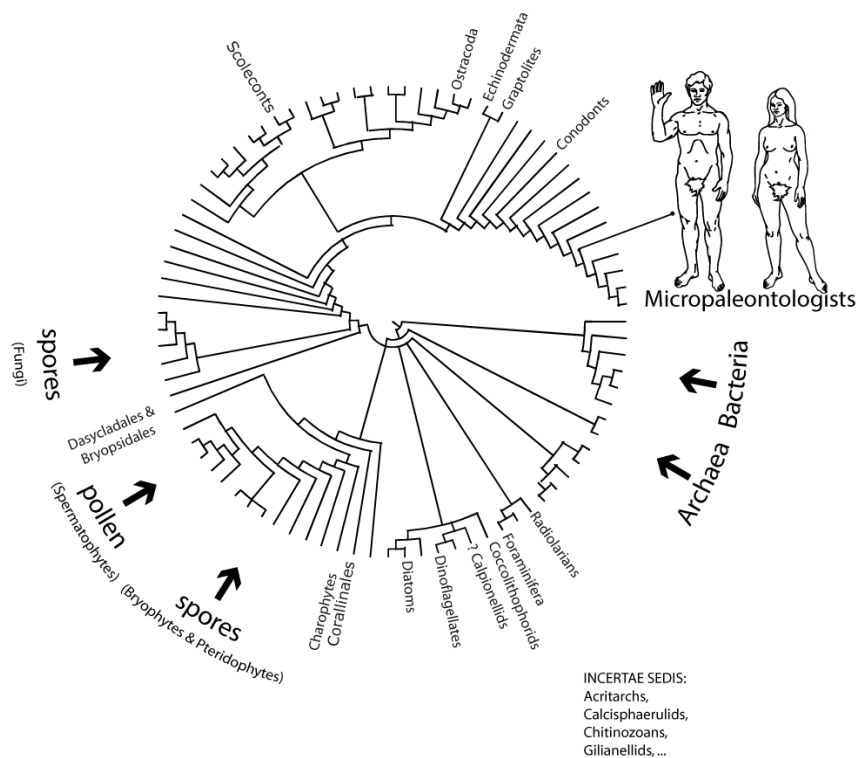


Fig. 1 – The diversity of the micropaleontological fields, modified from Mathieu *et al.* (2011).

Now let us leave this systematics aspect of micropaleontology and move to its practical use in the framework of biostratigraphy or more precisely microbiostatigraphy.

Microbiostatigraphy

The concept in biostratigraphy is that of biozone, a tool for dividing the time-stratigraphic scale in elementary units on the basis of the known ranges of microfossils. There are several kinds of biozones, such as: 1) the acrozone, which corresponds to the total range of a single species, from its FAD (first appearance datum)

upward to its LAD (last appearance datum); 2) the cenozone, based on an assemblage of species; 3) the interzone, a zone sandwiched in between two others and that lacks a specific marker; 4) the acme zone, marked by the abundance of one species; 5) the phylozones, based on a segment of phyletic lineage.

At this stage, we should highlight that there are two discrete domains of application of this tool: the “easy” domain which corresponds to the rather continuous basinal record and the “tricky” domain which includes the shallow-water (as well as continental) areas where frequent hiatuses make the sedimentary and fossil records incomplete. Standard biozones have been developed in basinal domains and helped defining accurately the stages. Actually, nowadays, stage are not strictly defined by the interval they span but by their sole lower boundary with a reference to a GSSP (Global Boundary Stratotype Point), and one of the common proxies used to define the latter is not a biozone itself but the FAD or the LAD of a microfossil species. Microfossils gradually take over macrofossils, mainly because they are more abundant and diverse in a given volume of rock. Miocene stage boundaries are defined by FAD of planktonic foraminifers, as well as the Cenomanian GSSP; in contrast, Oligocene stage boundaries are defined by LAD of planktonic foraminifers; Eocene stage boundaries are defined by LAD of nannofossils; FAD of conodonts are used for Ordovician, Devonian, Carboniferous, Permian and Triassic stages. The main reason for the early development of foraminiferal research was a limitation in the volume of rock available through drilling by oil and gas explorationists. Their study material consists mainly of well cuttings, occasionally of cores; they commonly require quick answers to ascertain the stratigraphic levels they are penetrating. Because “economic micropaleontologists” recognize the stratigraphic section from top to bottom, which is the reverse of the natural deposition, practical micropaleontologists have developed in house biozonation schemas, where most biozone boundaries are defined by the first occurrence downhole (actually a LAD).

Later on, oil and gas exploration contributed also to the development of palynology, which was more appropriate to investigate siliciclastic deposits (particularly those outside the paleotropical “carbonate” realm). Scientific programs of subocenic research, like Deep Sea Drilling Project (DSDP), Ocean Drilling Program (ODP) and Integrated Ocean Drilling Program (IODP), imply to have complete and continuous coring records (a luxury that oil companies cannot afford for economical reasons). These programs have led to the development of nannofossil stratigraphy, which was also eased by parallel technical progress, such as electronic microscopy. The “good” index microfossils include the planktonic foraminifers (Cenozoic to mid-Cretaceous), the nannofossils (Cenozoic to Late Jurassic), the calpionellids (Early Cretaceous to latest Jurassic), and, to some extent, the dinoflagellates (Cenozoic to Jurassic), the fusulinids (Permian to Late Carboniferous), the conodonts (see above) and the chitinozoans (Devonian to Ordovician). Except for the fusulinids, which are large benthic foraminifers living in shallow-water areas of Late Carboniferous and Permian tropical seas, all these index microfossils are abundant in the “easy” basinal domain, but rare or absent in the “tricky” shallow-water domain. But this domain too requires time ascription and though there are not considered as the best index microfossils, some large benthic foraminifers or some calcareous green algae may provide valuable information, at least in term of relative timing, eventually in term of dating. The pending problem is the calibration of these shallow-water zones to the basinal ones. Local occurrences of basinal fossils in shallow-water facies might help but because this information is rare and scattered, this approach implies successive approximations. Alternatively one can look for shallow-water markers in basinal environments, for instance in turbidite facies. The results might at first sight look puzzling: the precocious first occurrence of the well known *Palorbitolina lenticularis* in lowermost Barremian strata is just a recent example (Granier *et al.*, 2013).

Microfacies

Microfacies, with its variants nannofacies and palynofacies, provide information on the environments. At first sight, there is no direct connection to dating strata, but environmental changes correspond to events that can be correlated (Rost & Riebesell, 2004). Case studies are well illustrated by nannofossil events in mid-Cretaceous times (Giraud & Mattioli, 2010).

In shallow-water environments the microfossil assemblages at a given location change following relative sea-level variations. They record stillstand, shallowing or deepening upward trends that can be used in sequence stratigraphy. As such some fossils which were not considered “good” stratigraphic markers can provide very

valuable information. An example exposed by Granier *et al.* (2003) concerns the Hawar and Shu'aiba of the Middle-East: seismic stratigraphers usually identify the two units as a single transgressive-regressive cycle but trends detected from the microfacies, *i.e.*, a combination of foraminiferal and algal contents and sedimentary features, demonstrate that there are two discrete cycles with a major sequence boundary in between.

Conclusion

We hope that STRATI2013 will remain as one of the occasions to document refinements in the “easy” domain and their implications, as well as to illustrate amazing conclusions derived from the fair use of the limited information available from the “tricky” domain.

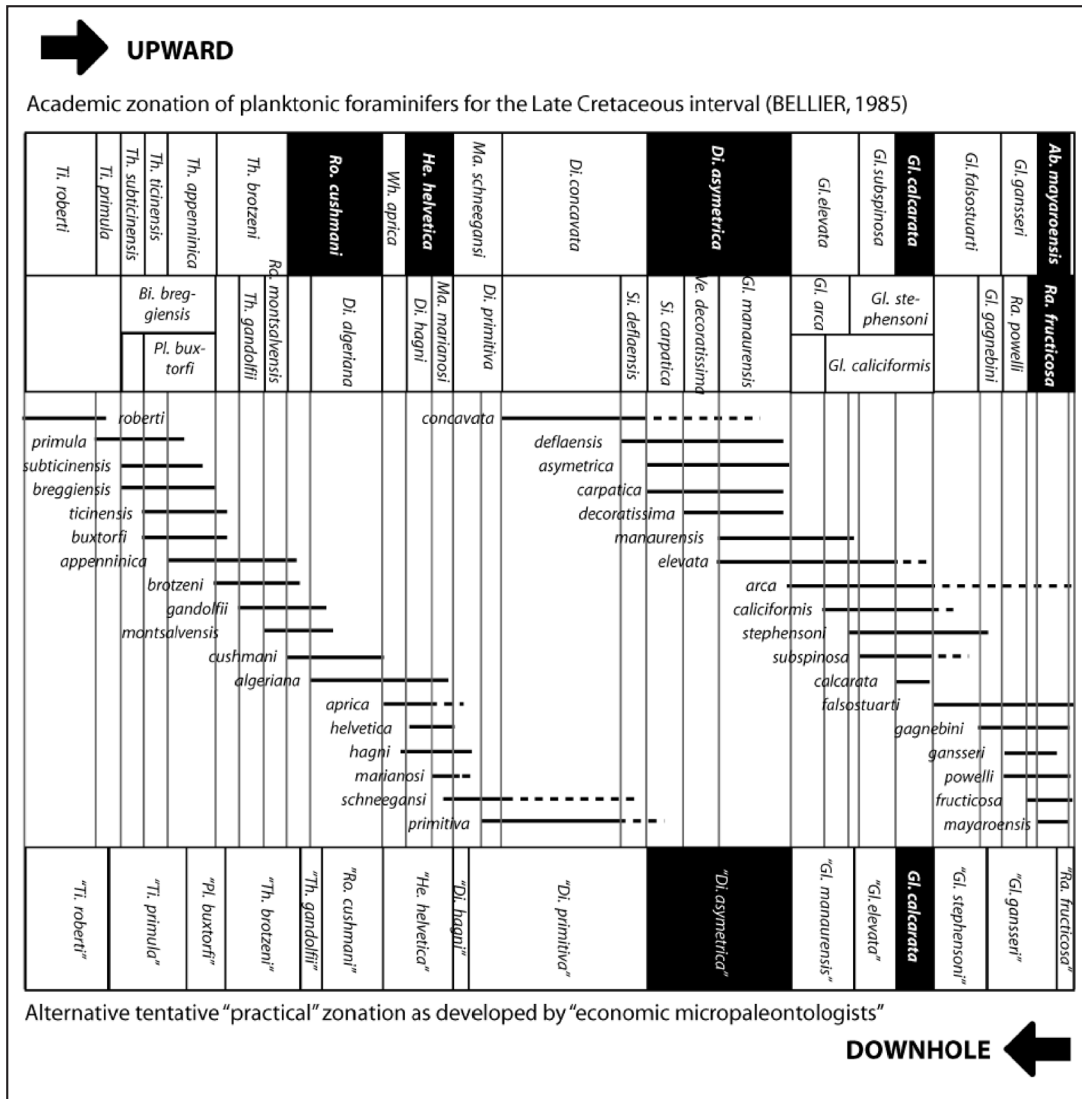


Fig. 2 – Academic zonation of planktonic foraminifers for the Late Cretaceous interval (Bellier, 1985), on the left column of the figure, versus an alternative tentative “practical” zonation as developed but never published by “economic micropaleontologists”.

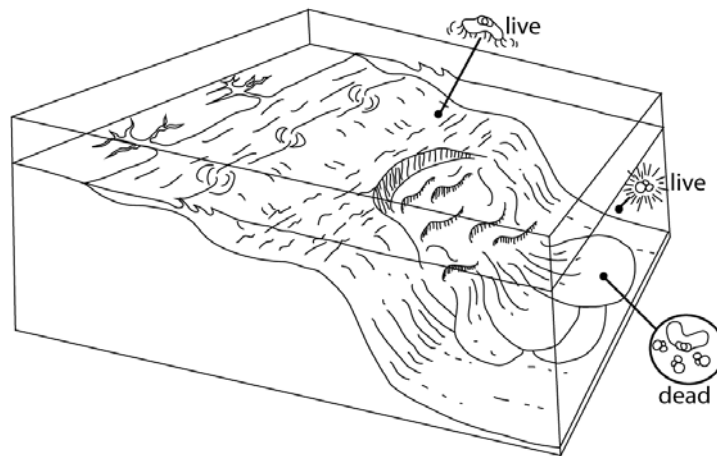


Fig. 3 – The turbidites, the strata where the shallow-water microfossils meet the “good” basinal fossils.

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References

- BELLIER J.-P. (1985) – Foraminifères planctoniques du Crétacé de Tunisie septentrionale: systématique, biozonation, utilisation stratigraphique de l’Albien au Maastrichtien. *Mém. Soc. géol. Fr.*, Nouv. sér. 146, 67 p.
- BIGNOT G. (2001) – *Introduction à la micropaléontologie*. Gordon and Breach Science Publishers, Paris, 258 p.
- BOLLI H. M., SAUNDERS J. B. & PERCH-NIELSEN K. (1985) – *Plankton stratigraphy*. Cambridge University Press, Cambridge Earth Science Series, 1032 p.
- BRASIER M. D. (1980) – *Microfossils*. George Allen & Unwin, London, 193 p.
- GIRAUD F. & MATTIOLI E. (2010) – Foreword for the thematic volume of 12th INA. Recent advances in living coccolithophores and calcareous nannofossil studies. *Geobios* 43(1), 1-13, doi:10.1016/j.geobios.2009.12.001.
- GRANIER B., AL SUWAIDI A. S., BUSNARDO R., AZIZ S. K. & SCHROEDER R. (2003) – New insight on the stratigraphy of the "Upper Thamama" in offshore Abu Dhabi (U.A.E.). *Carnets Géol.*, Article 2003/05 (CG2003_A05_BG_et al.), 17 p., doi:10.4267/2042/297.
- GRANIER B., BUSNARDO R., CLAVEL B., MOULLADE M., CHAROLLAIS J., TRONCHETTI G. & DESJACQUES P. (2013) – Refurbishing the Urgonian biostratigraphy: A key section at L’Estellon, Drôme, France. STRATI 2013, Lisboa, 1-7 July, Abstract Volume. *Ciências da Terra*, vol. sp. VII.
- HAQ B. U. & BOERSMA A. (Eds.) (1978) – *Introduction to marine micropaleontology*. Elsevier, New York, 376 p.
- MATHIEU R., BELLIER J.-P. & GRANIER B. (Eds.) (2011) – *Manuel de Micropaléontologie*. Carnets Géol., Livre 2011/02 (CG2011_B02), 123 p., doi: 10.4267/2042/45793.
- MOLINA E. (Ed.) (2002) – *Micropaleontología*. Prensas Universitarias de Zaragoza, Colección Textos docentes, 634 p.
- MOULLADE M., TRONCHETTI G. & BELLIER J.-P. (2005) – The Gargasian (Middle Aptian) strata from Cassis-La Bédoule (Lower Aptian historical stratotype, SE France): planktonic and benthic foraminiferal assemblages and biostratigraphy. *Carnets Géol.*, Article 2005/02 (CG2005_A02), 20 p., doi:10.4267/2042/1460.

- ODIN G.S. & LETHIERS A. (2006) – Nouvelles études micropaléontologiques sur le stratotype de la limite Campanien-Maastrichtien à Tercis (SO France): les gilianelles (microproblematica) extraites par acétolyse. *Carnets Géol.*, Article 2006/05 (CG2006_A05), 28 p., doi: 10.4267/2042/6697.
- ROST B. & RIEBESELL U. (2004) – Coccolithophores and the biological pump: responses to environmental changes. In THIERSTEIN H. R. & YOUNG J. R. (Eds.), *Coccolithophores, from molecular processes to global impact*. Springer-Verlag, Berlin Heidelberg, 99–125.