The Gargasian (Middle Aptian) of Cassis-La Bédoule (Lower Aptian historical stratotype, SE France): geographic location and lithostratigraphic correlations

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Mots-Clefs : Stratigraphie ; Crétacé ; Aptien ; Gargasien ; Bédoulien ; stratotype ; France

In the middle of the last century Gargasian strata overlying the historical stratotypic beds of the lower substage of the Aptian (Bedoulian) were still well exposed in a number of quarries that extended in a NNE-SSW trending belt from the village of Roquefort-la Bédoule to the vicinity of the Cassis railway station (Fig. 1).

In the La Bédoule region these quarries first supplied the nearby lime kilns abandoned early in the 19th century, and then the Lafarge cement plant near the Cassis railway station. By the middle of the 20th century their exploitation had stopped completely and the plant had shut down. The lack of replacement activity, urbanization and the beginning of some rehabilitation has had a deleterious effect, so that in our day only the large and southwesternmost quarry called "La Marcouline" (Fig. 2) allows us to investigate an almost continuous section of Gargasian strata about 70 m thick, of which the upper twenty meters are being rapidly degraded.

The following biostratigraphic investigation shows that the lower fifty meters, still in a state that permits detailed sampling, include only the lower Gargasian and the lower part of the middle Gargasian. The remainder of the series is represented by a broad brush-covered tract where some scattered outcrops of sandy marls of upper Gargasian and possibly Albian age were still visible in the sixties. Furthermore, blocks of talus from the cliff of Cenomanian limestones that caps the succession are scattered profusely on the brush-covered slope. The top of that resistant limestone forms a line of crests that are a prominent element of the topography from Cassis in the SSW to the Pas d'Ouillier in the NNE.

Although the two are almost in direct prolongation, it is impossible to correlate precisely the base of the Gargasian sequence in the La Marcouline quarry with that of the Bedoulian of the historical stratotype that was restudied in detail in 1998 (MOULLADE, TRONCHETTI & MASSE). The

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uppermost beds of the Bedoulian (*sensu* CONTE, 1994) crop out (less and less, alas) at the top of the Comte quarry, just below the D1 departmental road from Cassis to Roquefort-La Bédoule. They are separated from the Gargasian at La Marcouline by a covered zone, formed in part by the existence of the paved road at this place, but more substantially by the fact that the lowermost beds of the Gargasian, less resistant than beds of the Bedoulian below and the later Gargasian above, have flowed like mud and formed colluvium easily invaded by vegetation. So now these passage beds crop out almost nowhere in the entire area.

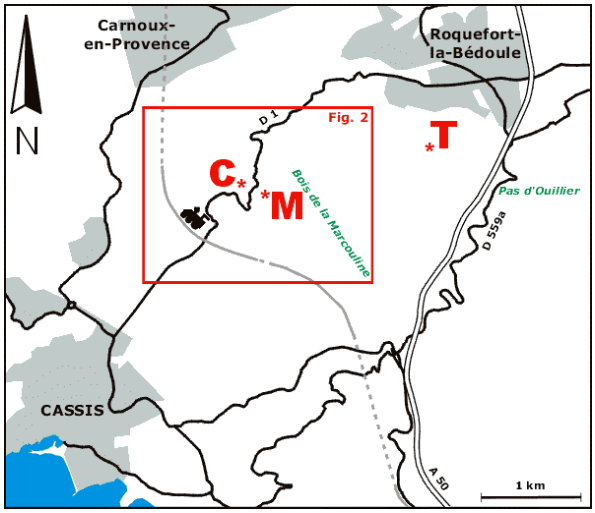


Figure 1: Map of the Cassis - Roquefort-La Bédoule area. C = Comte quarry; M = La Marcouline quarry; T = Les Tocchis section.

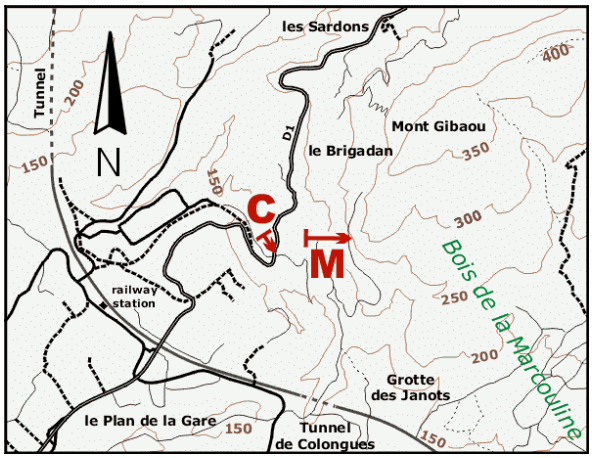


Figure 2: Map of the area near the Cassis railway station. C = Comte quarry; M = La Marcouline quarry.

The situation was different in the sixties, at least in the vicinity of La Bédoule, in a tract, now a development, "Les Tocchis", 2 km ENE of the La Marcouline quarry. At this site a simple piecemeal survey resulted in the recording of about 15 meters of an uninterrupted sequence beginning at the limestone of Bedoulian bed 170 (in the nomenclature used by MOULLADE *et alii*, 1998) and ending in a triplet of limestone beds in the basal Gargasian sequence, numbered 196, 197 and 198, slightly thicker and thus more conspicuous topographically than the remainder of the section (Fig. 3). The outcrops of this 15 m succession, more marly than the overlying and underlying beds, are today completely inaccessible because of urbanization. But in 1963 one of us mapped and sampled it in detail (M.M.). We are now able to link the uppermost beds of the Comte quarry with the lowermost at La Marcouline only with the help of this Les Tocchis section and in particular the samples collected then (Fig. 3).

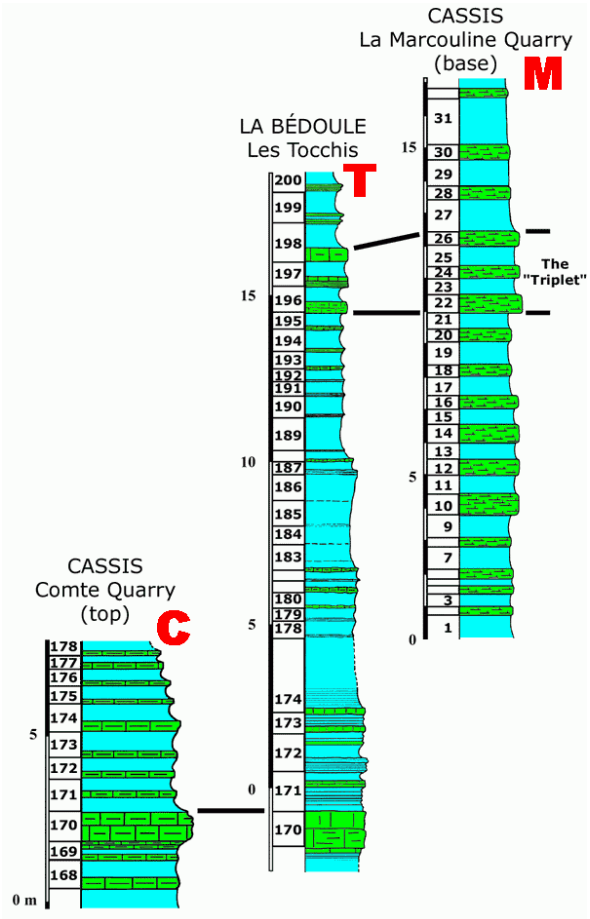
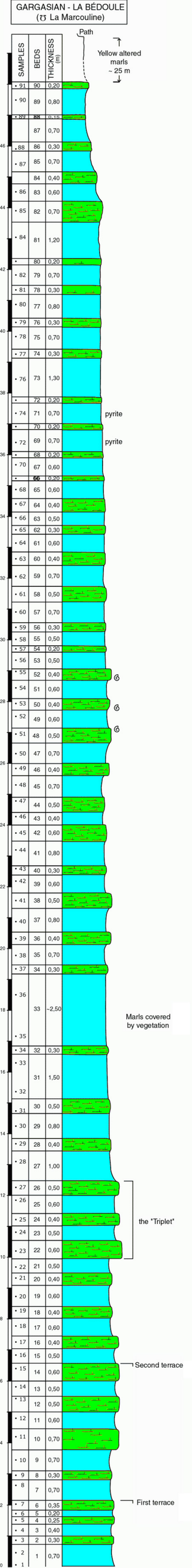


Figure 3: Lithostratigraphic correlation of the Bedoulian-Gargasian transition using the Comte quarry (C), Les Tocchis (T) and La Marcouline quarry (M) sections as successive relays.

A direct lithostratigraphic correlation between the Les Tocchis section and the presumably equivalent sequence at La Marcouline is rather difficult. The outcrops at Les Tocchis were both eroded and weathered. So harder beds there were conspicuous, whereas at La Marcouline the beds are in a steep, recently-worked face so differences in the weathering profiles of hard and soft beds is less pronounced. In addition, the thicknesses of some beds seem to be different in the two sites.

Figure 4: Gargasian section at La Marcouline quarry. ▶▶


GARGASIAN - LA BÉDOULE
(ʊ La Marcouline)
SAMPLES
BEDS
THICKNESS (m)
Path
Yellow altered marls ~ 25 m
pyrite
pyrite
Marls covered by vegetation
the "Triplet"
Second terrace
First terrace

As mentioned, in the Les Tocchis section the 196-197-198 limestone beds made up a hard triplet marker, clearly defined and forming a relief. At La Marcouline the basal succession has at least three triplets: beds 2-4-6; beds 10-12-14; beds 22-24-26, all of them more or less alike and geometrically capable of representing the triplet at Les Tocchis. As it turned out, the last was slightly more prominent than the other two (Fig. 3).

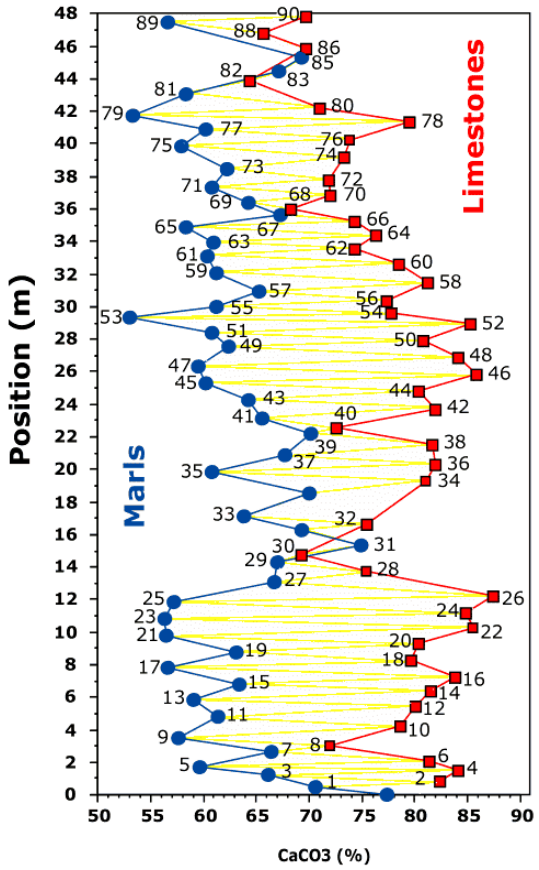


Figure 5: Variation in the $CaCO_3$ content of the marly (dots) and limy (squares) Gargasian beds in the La Marcouline quarry section.

Consequently, it was necessary to use biostratigraphy to calibrate these three groups with more accuracy and thus to arrive at a precise correlation of the Les Tocchis triplet 196-197-198 with beds 22-24-26 at La Marcouline (Fig. 3)

In fact the double micropaleontologic datum based on the simultaneity of the first appearance of the planktonic foraminifer *Globigerinelloides ferreolensis* (MOULLADE) and the disappearance of *Schackoina* (*Leupoldina*) *cabri* SIGAL occurs at La Marcouline 3.5 m below the base of bed 22, the lowermost of the triplet 22-24-26 (MOULLADE *et alii*, this volume). At Les Tocchis, the sampling of that time was a little less closely spaced. Nevertheless this datum was found 3.3 m under bed 196, the lowest of the 196-197-198 triplet. The foraminiferal correlation is supported by the distribution of the calcareous nannofossils (BERGEN *et alii*, this volume).

The equivalent of marker bed 170 near the base of the Les Tocchis section is also clearly recognizable in the Cassis sequence (Comte quarry). So, using Tocchis as an intermediate point, it was possible to calibrate the La Marcouline section to the Bedoulian stratotype (Fig. 3)

At first glance the Gargasian sequence cropping out at Marcouline (Fig. 4) is distinguished by its marked rhythmicity caused by a fairly regular alternation of "limestones" and "marls". Calcimetric analyses (RENARD *et alii*, this volume) show that the well-marked difference in weathering pattern has only a slight relationship with the composition of the strata: calcium content ($CaCO_3$) ranges from 53 per cent in the most marly interbeds to 87.5 per cent in the most limy levels. The entire sequence can be split into several second order cycles that are differentiated mainly by changes in the amount of divergence between the limiting percentages (Fig. 5). We shall not discuss here the details of these analyses and the possible significance of the cyclicity. These topics are developed in full elsewhere in this volume (RENARD *et alii*; KUHNT & MOULLADE) and in addition will be compared (see the final chapter of syntheses in this volume) with the findings of the micropaleontologic analyses in order to refine paleoenvironmental and paleoclimatic interpretations.

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