Mapping of a pelagic carbonate platform/basin system in the Rossa Mts. (Central Apennines)

Fabrizio GALLUZZO* & Massimo SANTANTONIO**

* APAT-Dipartimento Difesa del Suolo, Roma, Italia
** Dipartimento Scienze della Terra, Università di Roma "La Sapienza", Roma, Italia

ABSTRACT

The purpose of this paper is to illustrate the Jurassic palaeogeographic and structural evolution, and the complex geometries of a small-scale pelagic carbonate platform/basin system from the Rossa Mts. area (Marche Apennines). Geological mapping, biostratigraphy, and sedimentology were the key tools used to achieve our goals. In our geological map we propose *ad hoc* symbols to represent the Jurassic faults and several types of stratigraphic contacts, including paraconformities and high- and low-angle unconformities, all typical of these peculiar carbonate depositional systems. This hopefully results in a clearer description of the primary three-dimensional features of individual sedimentary bodies, also emphasizing the distribution of key discontinuity surfaces.

AIMS

Geological mapping of a pelagic carbonate platform sector. Evolution of Jurassic palaeoescarpments. Palaeogeographic reconstruction. Use of experimental map symbols.

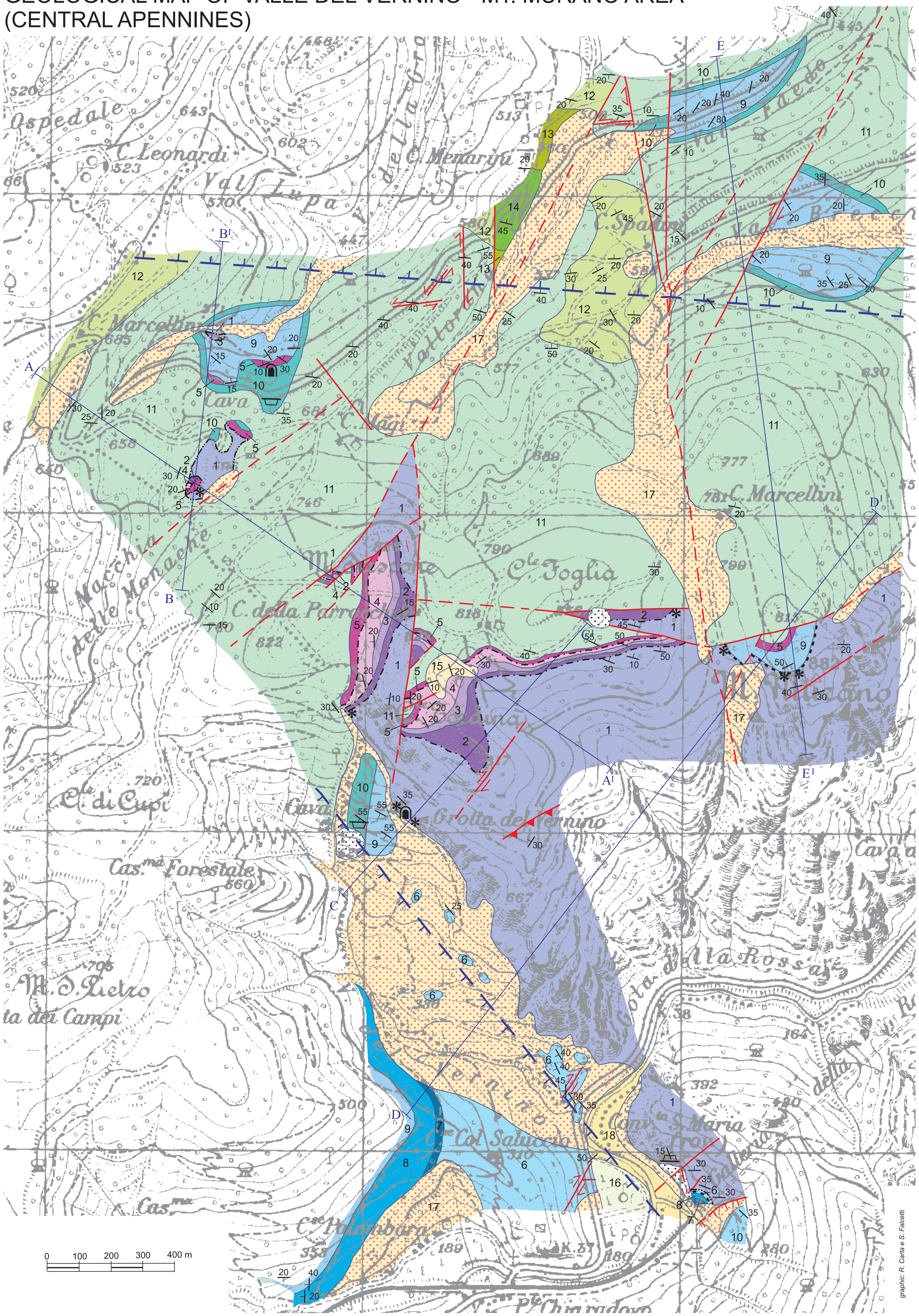
KEYWORDS

Jurassic, pelagic carbonate platforms, Umbria-Marche Apennines.

RIASSUNTO

Da un rilevamento geologico di dettaglio, integrato da osservazioni biostratigrafiche e sedimentologiche, è stato possibile ricostruire l'evoluzione paleogeografico-strutturale giurassica e i complessi rapporti geometrici del sistema piattaforma carbonatica pelagica/bacino che caratterizza l'area dei Monti della Rossa (Appennino marchigiano). Nella carta è stata data particolare importanza alla rappresentazione, tramite apposite simbologie, delle faglie giurassiche e dei tipi di contatto stratigrafico, differenziando tra paraconcordanze e discordanze angolari ad alto e basso angolo. E' stato in questo modo possibile dare una visione più immediata dei rapporti geometrici e delle variazioni latero-verticali dei corpi sedimentari.

GEOLOGICAL MAP OF VALLE DEL VERNINO - MT. MURANO AREA (CENTRAL APENNINES)



QUATERNARY DEPOSITS

18 - Recent alluvial deposits, mainly gravel
Holocene

17 - Talus deposits, locally cemented
Holocene

16 - Terraced alluvial deposits, mainly gravel
?Pleistocene

15 - Clinostratified cemented breccias
?Pleistocene

BASINAL SUCCESSION

14 - **Scaglia rossa** - Reddish marly limestones and calcareous marls, in thin and medium beds, with ribbons and nodules of red chert.
Lower Turonian p.p. - Middle Eocene p.p.

13 - **Scaglia bianca** - Whitish limestones and marly limestones, in thin and medium beds, with ribbons and nodules of black chert.
Upper Albian p.p. - Lower Turonian p.p.

12 - **Marne a Fucoidi** - Polychrome marly limestones, marls and clayey marls, thinly bedded.
Lower Aptian p.p. - Upper Albian p.p.

11 - **Maiolica** - White and light brown limestones, in thin and medium beds, with ribbons and nodules of chert, black near the top. At Colle Foglia - Colle Tordina - Mt. Murano chert is missing or rare, and dolomitized levels are widespread. Locally, the basal levels are ammonitiferous.
Upper Tithonian p.p. / Berriasian - Lower Aptian p.p.

10 - **Calcari a *Saccocoma* e aptici** - White to red limestones, marly limestones and marls, thinly bedded, showing three different lithofacies: a) red marls; b) nodular red marly limestones, bioturbated, with aptychi, ammonites and belemnites; c) white and pink limestones rich in *Saccocoma*, with aptychi and rare irregular echinoids; bedding planes can display ripple marks. Locally, greenish limestones with chert and abundant pyrite and bluish clays interbedded, with ammonites and rare microsolenid corals.
Lower Tithonian p.p. - Upper Tithonian p.p./Berriasian

9 - **Calcari diasprigni** - Cherty limestones and polychrome cherts, sometimes nodular, thinly bedded, with very thin pelitic interbeds. Locally (Val Brecciara), turbiditic calcarenites with crinoids, rhyncholites, oolites, calcareous algae, *Tubiphytes morronensis* Crescenti, *Trocholina sp.*, etc.
?Bathonian/Callovian - Lower Tithonian

8 - **Calcari e marne a Posidonia** - Whitish limestones and marly limestones, in thin and medium beds, with ribbons and nodules of polychrome chert, more abundant upward, with "filaments" and very rare ammonites.
Upper Toarcian p.p. - ?Bathonian/Callovian

7 - **Rosso ammonitico** - Nodular marly limestones and reddish marls with micritic soft-pebble levels, rich in ammonites. "Filaments" occur in the upper part.
Lower Toarcian p.p. - Upper Toarcian p.p.

6 - **Corniola** - Grey or hazel limestones, in thin and medium beds, with ribbons and nodules of chert. The lower part bears turbiditic levels, sometimes with conglomeratic base, and olistoliths of Calcare Massiccio.
Lower Sinemurian p.p. - Lower Toarcian p.p.

PELAGIC CARBONATE PLATFORM SUCCESSION

5 - **Bugarone superiore formation** - Whitish to hazel limestones, often nodular, thinly bedded, with aptychi, belemnites, rhyncholites, crinoids, bivalves, brachiopods, isolated and colonial microsolenid corals, and abundant ammonites. Protoglobigerinids in the lower part. Locally dolomitized in the upper part.
Lower Kimmeridgian p.p.- Upper Tithonian p.p.

4 - **Bugarone inferiore formation** - White-greenish nodular marly limestones and dolomitized limestones, in thin and medium beds, often nodular and bioturbated, with "filaments", protoglobigerinids in the upper part, gastropods and ammonites.
Upper Toarcian p.p. - Lower Bajocian

3 - **Rosso ammonitico - equivalente** - Yellow-ochre nodular marly limestones, bioturbated, with abundant pyrite, with crinoids, brachiopods, "filaments" and abundant ammonites.
Lower Toarcian p.p. - Upper Toarcian p.p.

2 - **Corniola - equivalente** - Light brown or hazel limestones, generally thinly bedded. The lower part contains abundant crinoids, brachiopods, bivalves, gastropods, echinoids, sponge spicules and ammonites. The top is a limonitic hard-ground.
Upper Pliensbachian - Lower Toarcian p.p.

CARBONATE PLATFORM SUCCESSION

1 - **Calcare Massiccio** - White limestones in very thick beds, often with peritidal cycles. Peloids and intraclasts are dominant, with green algae, echinoids, molluscs and rare corals. Oolitic levels are rare. The top locally bears a siliceous-limonitic crust. Locally (Mt. Murano, Vernino Cave) the formation has chert nodules (*).
Hettangian - Sinemurian p.p.

Continuous stratigraphic boundary

Paraconformity

High-angle angular unconformity

Low-angle angular unconformity

40 Bed dip

Fault (dashed where inferred)

Reverse fault (triangles towards the upthrown block)

Normal fault (barbs towards the downthrown block)

Strike-slip fault (dashed where inferred)

Fault with unspecified strike-slip movement (dashed where inferred)

Buried syn-sedimentary normal fault (barbs towards the downthrown block)

* Silicification

Cave

a b Active (a) inactive (b) quarry

Waste

A A' Trace of geological cross-section

Fig. 1 - *Geological map of the Valle del Vernino - Mt. Murano sector, Rossa Mountains, Central Apennines.*

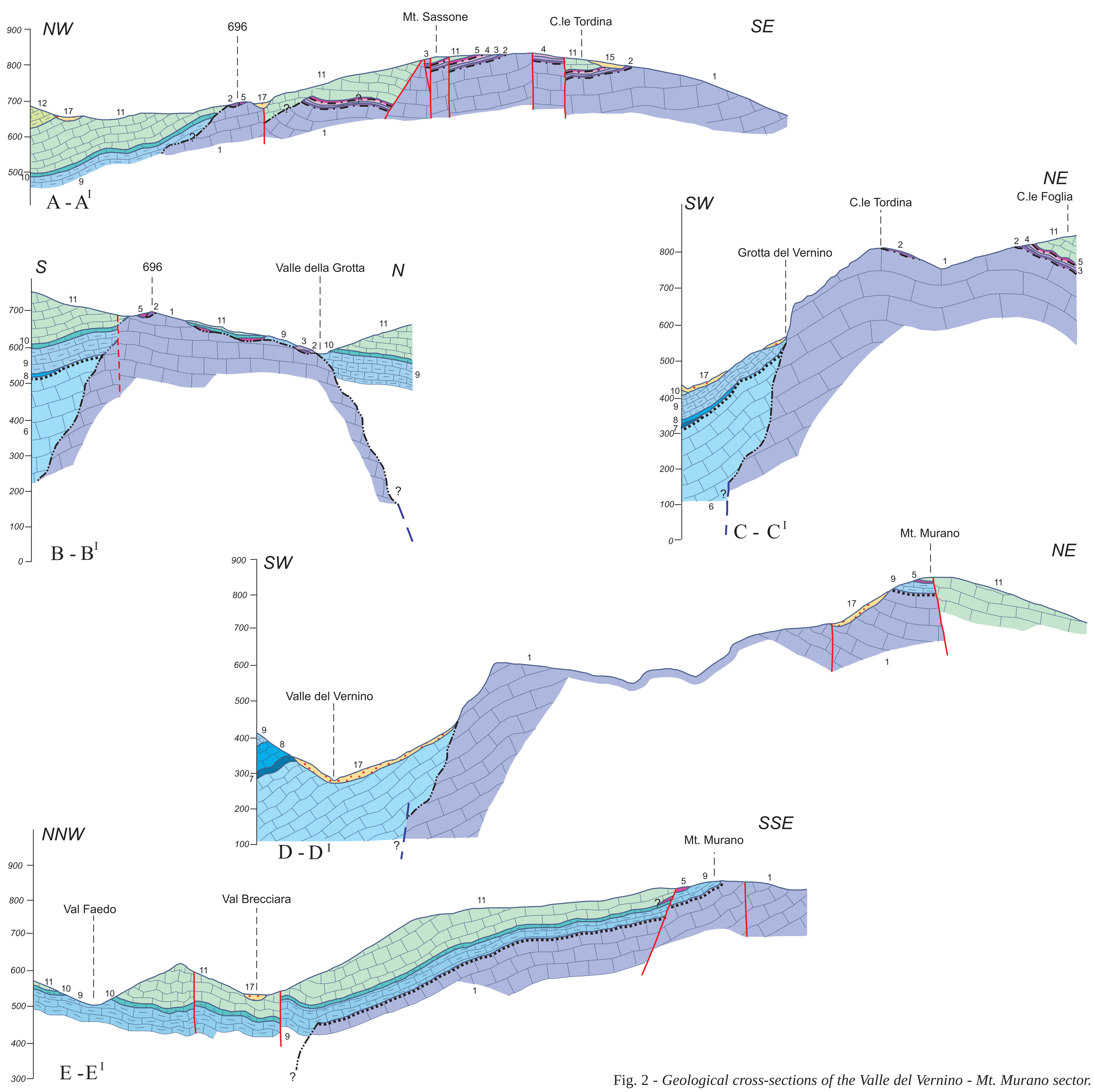


Fig. 2 - *Geological cross-sections of the Valle del Vernino - Mt. Murano sector.*

INTRODUCTION

This paper presents an example of geological mapping of a Jurassic pelagic carbonate platform (PCP)/basin system in the Marche Apennines of central Italy. Similar situations can be found from western to eastern Alps, through the northern and central Apennines, to northern Calabria and most of Sicily. Geological mapping in these settings is often challenging, and may require specific techniques.

GEOLOGICAL SETTING

The map area is characterised by the typical Umbria-Marche pelagic succession. The lowest unit in outcrop is the Calcare Massiccio Fm., meant here in a broad sense, indicating peritidal carbonate conditions, locally until the early Sinemurian. Rift tectonics then produced a pattern of fault-bounded intrabasinal highs and intervening basins. Following a regional drowning event in the early Pliensbachian, which turned the highs into PCPs, pelagic/hemipelagic sedimentation became dominant until the early Miocene, when it was replaced by inversion-related siliciclastics. Condensed sedimentation took place on the PCPs until Liassic rift basins were completely infilled in the Early Cretaceous. The PCPs were bordered by escarpments representing the morphological expression of rift-phase faults that had mostly become inactive. The palaeoescarpment tracts were sites of submarine erosion, occasional thin condensed sedimentation, and onlap by basinal units.
The stratigraphy and palaeostructure of the Jurassic of the Umbria-Marche region, and of the study area in particular, are described in papers by Centamore *et alii* (1971), Coltorti (1980), Galdenzi (1988), Santantonio *et alii* (1996) and Galluzzo & Santantonio (2002).
Fig. 3 represents a simplified geological sketch of the Marche Apennines. Figs. 4 and 5 provide stratigraphic correlations between idealized Jurassic basinal and PCP successions.

METHODOLOGY

Mapping was basically performed using the classical lithostratigraphic procedure. Jurassic pelagic formations were subdivided into two successions in the Legend: the “pelagic carbonate platform succession” and the “basinal succession”. The peritidal Calcare Massiccio, which underlies both types of successions, on its own represents the carbonate platform succession. Therefore, reference to these subdivisions provides instant indication of the general

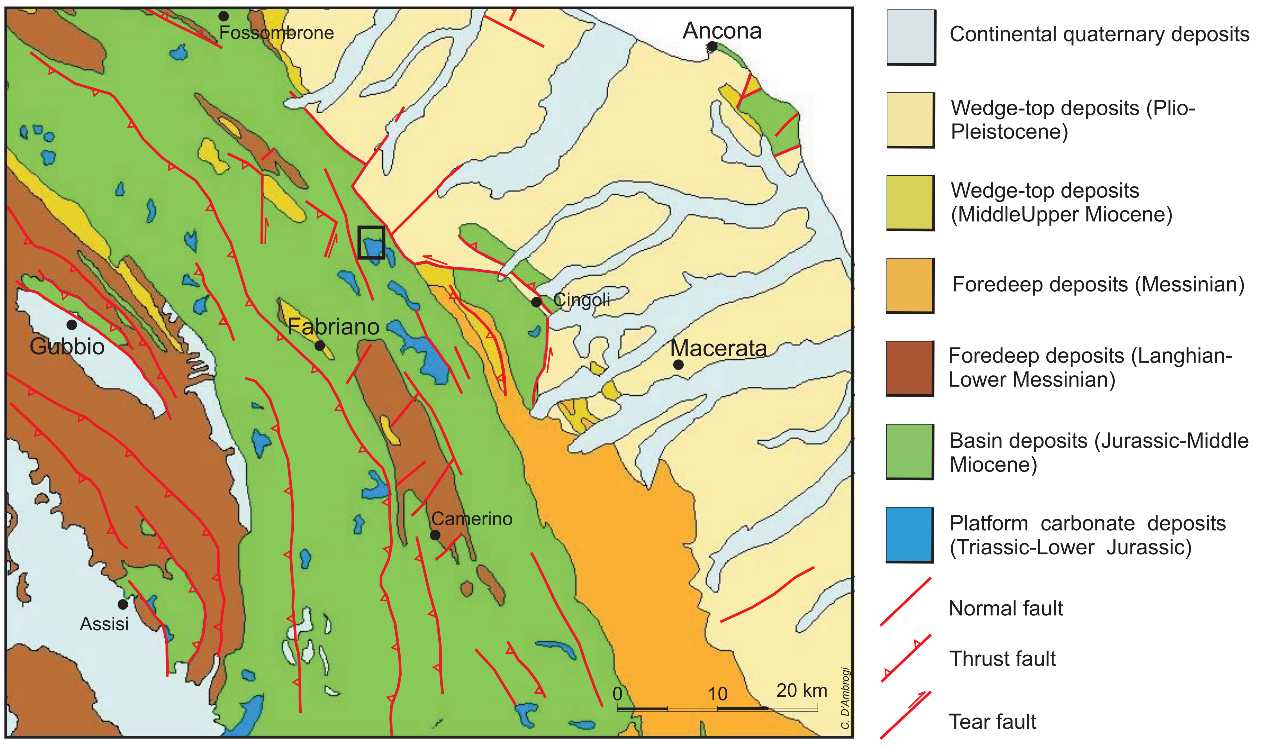


Fig. 3 - *Simplified geological sketch map of the Marche Apennines, with location of the study area, NE of Fabriano.*

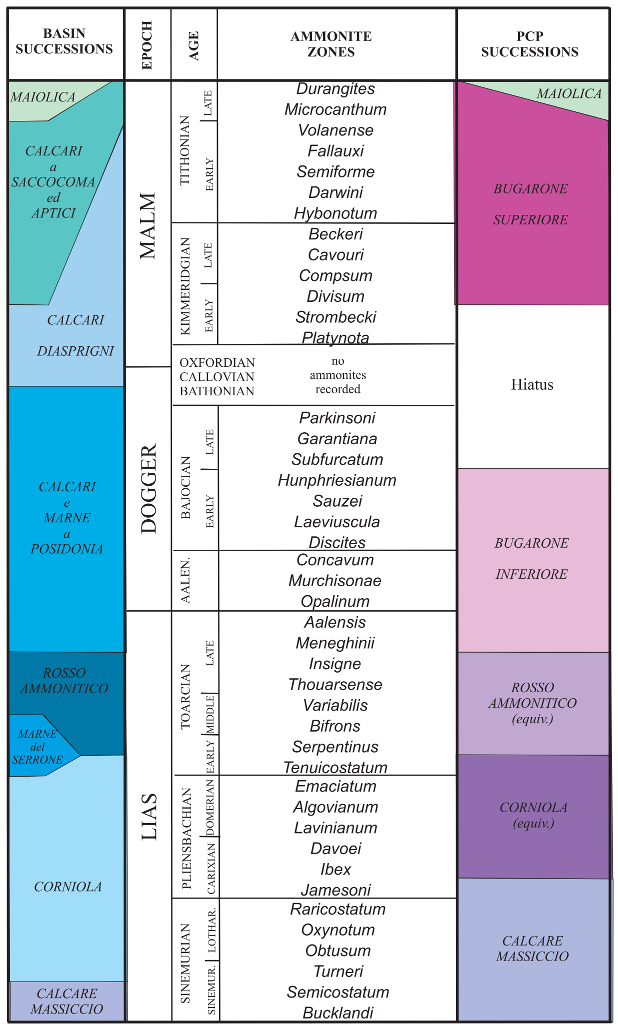


Fig. 5 - *Ammonite zones and litostratigraphic units (basin and PCP) of the Jurassic of the Umbria-Marche Apennines. No ammonites of the Hettangian, Bathonian, Callovian and Oxfordian have so far been found in the Umbria-Marche Apennines.*

depositional environment in which individual formations were sedimented.

Fig. 6 provides correlation of three lithostratigraphic columns of the study area.

While recognizing end-member successions like those mentioned above is the first essential step towards tackling the stratigraphy of the region, there are several "grey zone" situations where the stratigraphy is puzzling and the complexity of local 3D geometries prevails over the very notion of vertical succession. The lithostratigraphic method was therefore integrated with the use of the facies associations by SANTANTONIO (1993) (Fig. 7), whose distribution in different sectors of the study area (Fig. 8) provides key additional information for interpreting the geometries, areal extent and dynamics of individual sedimentary bodies in their depositional environments.

The **normal and resedimented pelagic facies association** is characteristic of basinal successions. It consists of pelagic and subordinate hemipelagic deposits with admixed gravity

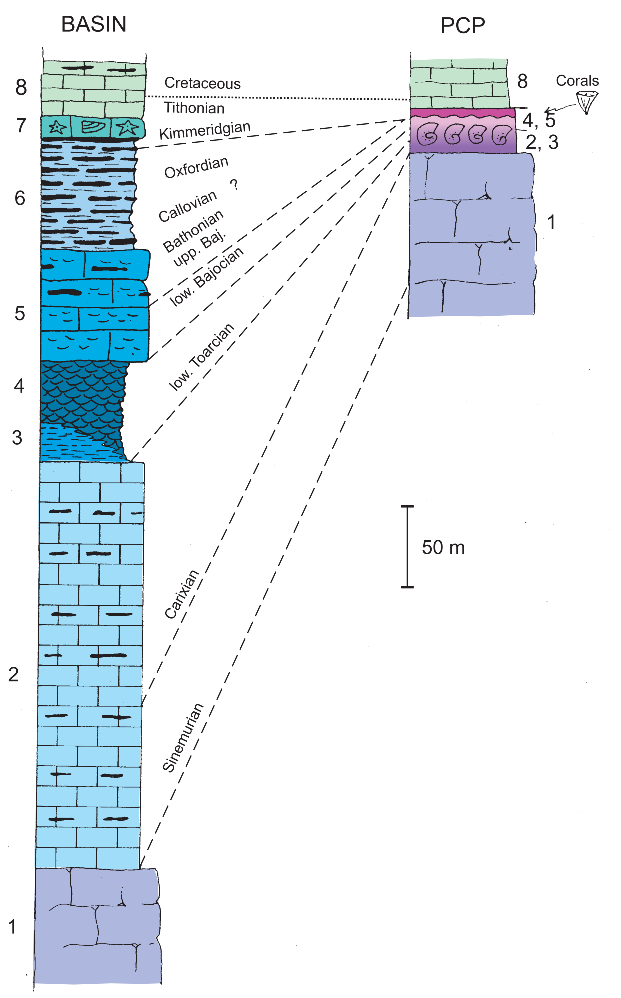


Fig. 4 - *Correlated stratigraphic columns of idealized PCP and basinal successions in the Jurassic of the Umbria-Marche Apennines. Dashed lines are time lines. The dotted line is the Jurassic/Cretaceous boundary. BASIN: 1. Calcare Massiccio; 2. Corniola; 3. Marne del Monte Serrone; 4. Rosso Ammonitico; 5. Calcari e marne a Posidonia; 6. Calcari diasprigni; 7. Calcari a* Saccocoma *ed aptici; 8. Maiolica.*
PELAGIC CARBONATE PLATFORM: 1. Calcare Massiccio; 2. corniola-equivalent; 3. rosso ammonitico-equivalent; 4. Bugarone inferiore formation; 5. Bugarone superiore formation; 8. Maiolica.

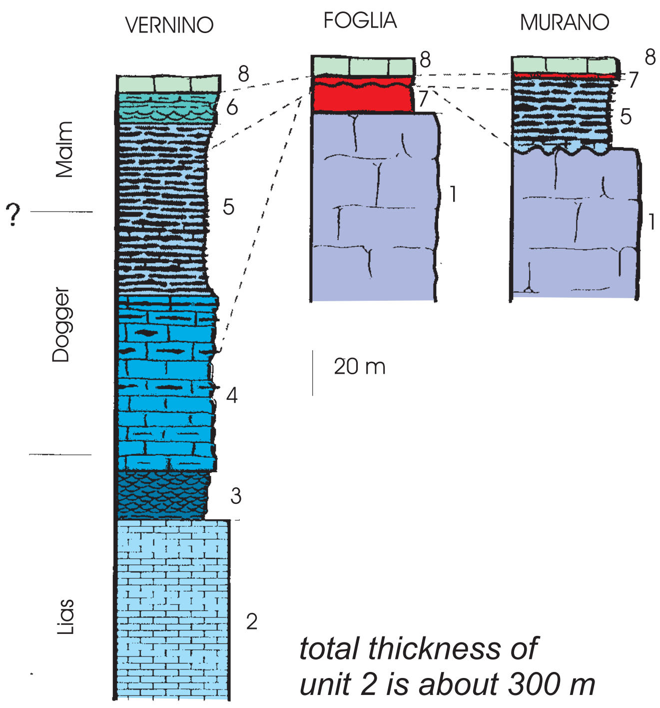


Fig. 6 - *Lithostratigraphic columns representative of the PCP and basin sedimentation at Valle del Vernino, Colle Foglia and Mt. Murano.*
1. Calcare Massiccio; 2. Corniola; 3. Rosso Ammonitico; 4. Calcari e marne a Posidonia; 5. Calcari diasprigni; 6. Calcari a Saccocoma ed aptici; 7. PCP sequence; 8. Maiolica. Dashed lines, meeting at the PCP Bajocian/Kimmeridgian unconformity (wavy line), define the basinal beds correlative to the hiatus.

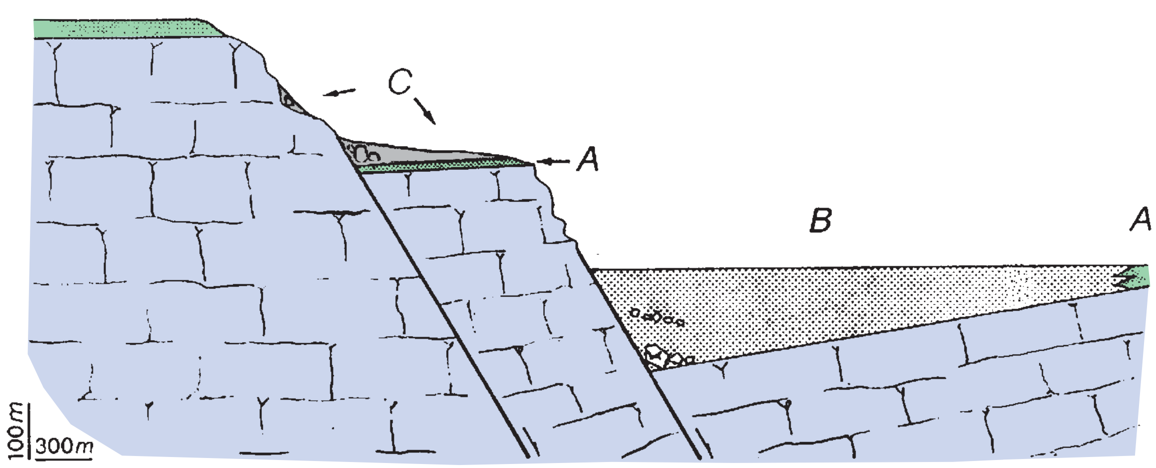


Fig. 7 - *The distribution of facies associations A (condensed pelagic), B (normal and resedimented pelagic), and C (composite pelagic) in a hypothetical PCP/stepped margin/basin depositional system.*

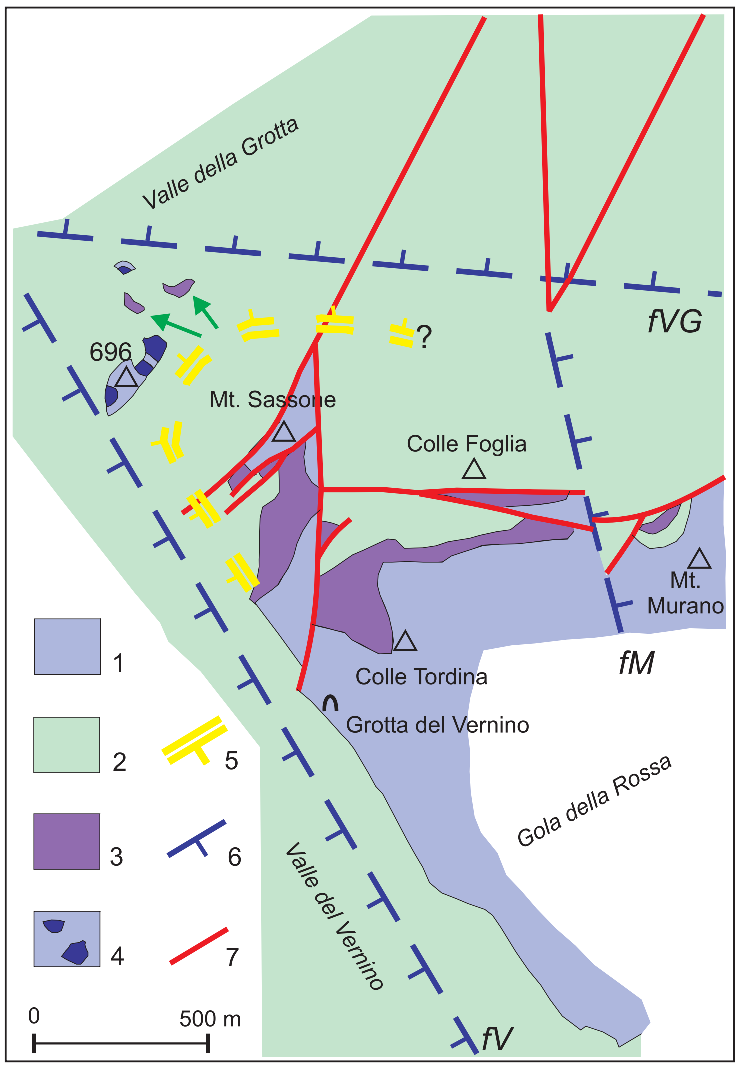


Fig. 8 - *Distribution of pelagic facies associations in the study area. 1. Calcare Massiccio; 2. normal and resedimented pelagic facies association; 3. condensed pelagic facies association; 4. composite pelagic facies association resting on Calcare Massiccio; 5. inferred edge of the pelagic carbonate platform; 6. Liassic faults: fVG Valle della Grotta fault; fV Vernino fault; fM Murano fault; 7. Neogenic faults. Green arrows indicate off-platform bodies of condensed pelagic facies association. Occurrence of the normal and resedimented pelagic facies association inboard the inferred PCP edge documents final draping by the Maiolica in the Early Cretaceous.*

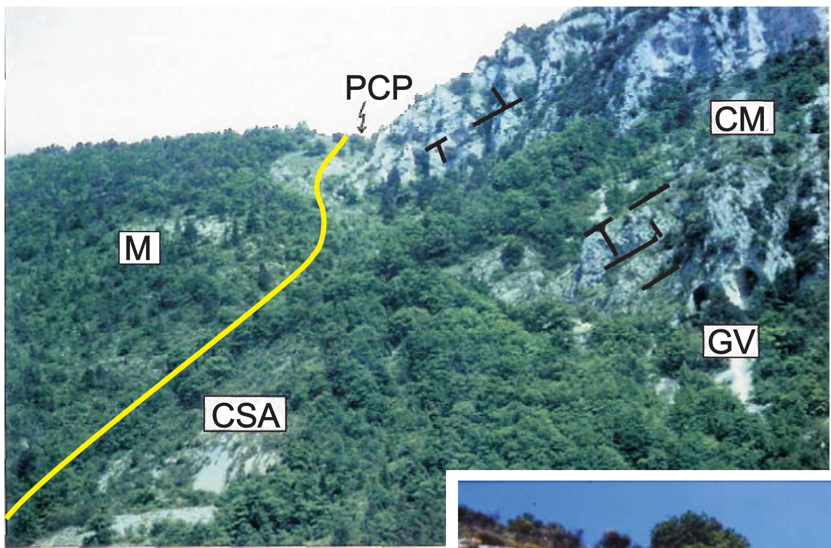


Fig. 9 - *Detail of the upper Vernino palaeoescarpment from the west. CM: steep walls of Calcare Massiccio; GV: Vernino cave; CSA: abandoned quarry in the Calcari a* Saccocoma *ed aptici, steeply dipping to the southwest; PCP: pelagic carbonate platform sequence; M: Maiolica Fm., onlapping the PCP. The yellow line marks the base of the Maiolica Fm..*

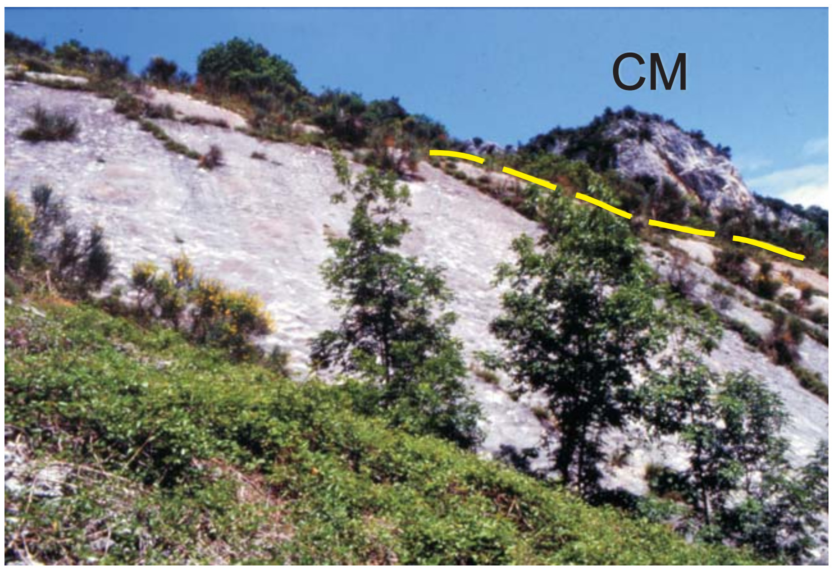


Fig. 10 - *Valle del Vernino. Bedding plane of the Calcari a* Saccocoma *ed aptici (CSA of the previous figure), beautifully rippled. CM indicates the Calcare Massiccio of the Vernino palaeoescarpment, which is unconformably abutted by the basinal pelagics. The yellow line is the onlap line.*

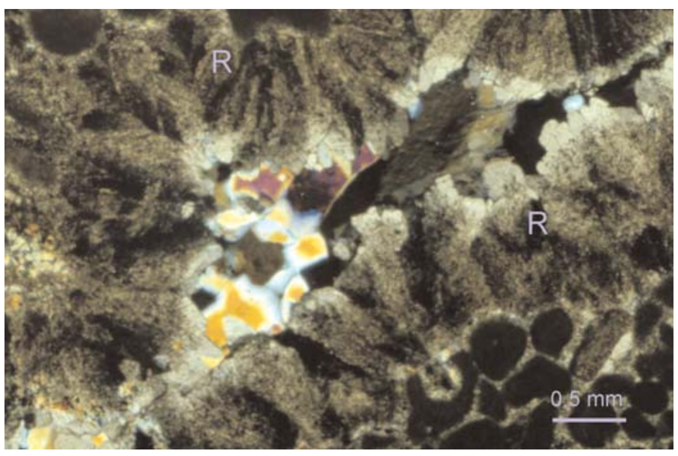


Fig. 11 - *Microphotograph of silicified Calcare Massiccio. Peloid/intraclast/skeletal packstone with laminoid cavity lined by early diagenetic thick fibrous radiaxal calcite (R) (note clear ends of crystals). Cavity center occluded by anhedral quartz.*
*This silicification is interpreted as the product of inflow of diagenetic fluids from the silica-rich, sponge - and radiolarian-bearing basinal cherty units into the Calcare Massiccio, which apparently must have still been porous, though lithified, during much of the Jurassic (*Santantonio *et alii, 1996). This diagenetic phase clearly predated the complete pore occlusion by blocky calcite that occurred at later pre-orogenic burial stages.*

flow and locally - near basin margins - rock-fall deposits.

In the area in question, this association is found east and north of the local intrabasinal high, abutting the local palaeoescarpment tracts, consisting of Calcare Massiccio, through angular unconformities (Figs. 9 and 10).

It is notable that the peritidal limestone is silicified locally at these unconformities. The detection of silicified Calcare Massiccio on the field - this formation as a rule has no cherty facies in itself - is a very useful field criterion for locating stratigraphic unconformities (Fig. 11).

The Valle del Vernino area also hosts turbidites, debrites and olistoliths in the Pliensbachian Corniola Fm. The local basin-margin succession is interesting in that it shows dramatic pinch-out of formations and unconformities which can be interpreted as being due to either synsedimentary fault rejuvenation or (more probably) to oversteepening and non-deposition/erosion, caused by differential compaction (Fig. 12).

The **condensed pelagic facies association** is typical of successions deposited on PCP-tops (and crest areas of tilted blocks), and it generally rests in geometrical concordance above the drowned Calcare Massiccio.

It is made of dominant whole-fossil, chert-free wackestones, often nodular, with common stratigraphic gaps and paraconformities indicating slow and discontinuous sedimentation with punctuated erosion. It is intriguing that deposits of this facies association can prograde outside the boundaries of PCPs, forming off-platform tongues with relatively little lateral continuity (a few hundreds of meters) which intercalate within basin-margin successions.

This facies association is found across the Colle Foglia - Colle Tordina - Mt. Sassone area (Fig. 13). Here the succession consists of four very thin formations bearing informal names, sometimes equivalent to those of the basinal units (e.g. corniola-equivalent).

Its maximum thickness is 16.5 m, but thins abruptly towards the PCP edges, where for example the rosso ammonitico-equivalent formation wedges out completely.

There are two main unconformities (paraconformities) in this sector: the lowest is the drowning unconformity flooring the pelagic succession; the other is a late Bajocian to earliest Kimmeridgian hiatus that is widespread regionally on PCPs, separating the Bugarone inferiore fm. from the Bugarone superiore fm.

Prograding tongues of the Bugarone superiore fm. (indicating the lower part of the lower Tithonian) occur sandwiched between the basinal Calcari diasprigni (radiolarian cherts) and the overlying Calcari a *Saccocoma* ed aptici at Valle della Grotta (Fig. 14), and below the Maiolica at Mt. Murano.

The **composite pelagic facies association** typically represents epi-escarpment sedimentation, being found in the form of thin discontinuous patches of condensed sediment resting on the substrate at PCP margins. In the map area, deposits with the composite pelagic facies association occur NW of Mt. Sassone and descending towards the abandoned quarry, representing an upper escarpment environment. Thin condensed deposits rest unconformably on the Calcare Massiccio (bearing centimetric chert

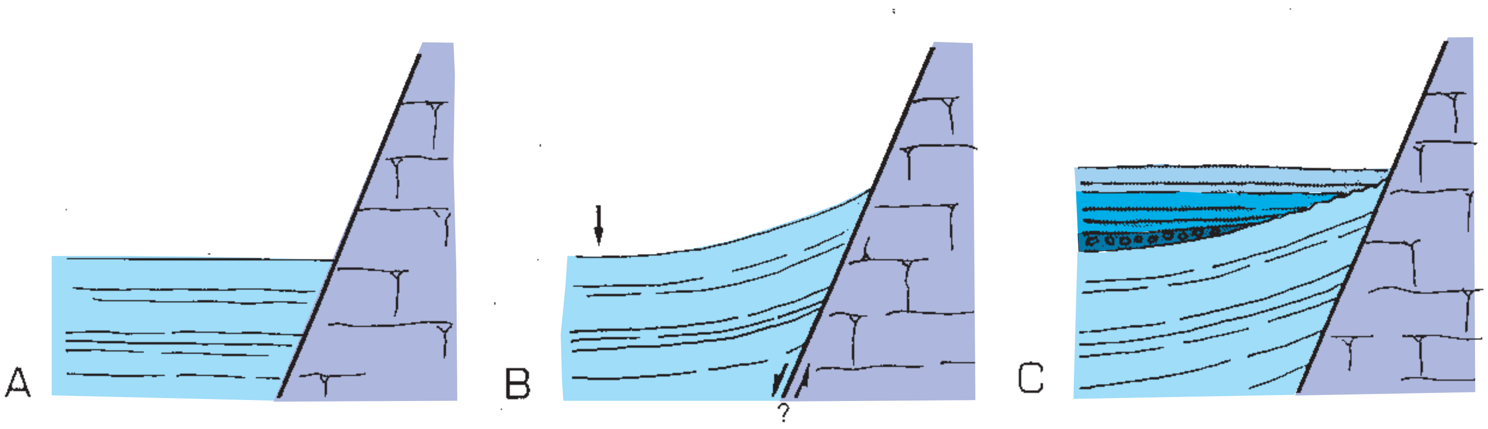


Fig. 12 - *The possible effects of synsedimentary fault rejuvenation or differential compaction on the geometry of pelagic formations.*
A*: before rejuvenation or compaction;*
B*: normal faulting or compaction causes normal drag of basinal strata, forming a secondary slope;*
C*: upwardly bent strata urdergo submarine erosion resulting in the triggering of debris flow to be found at the base of the next deposited pelagic sequence, which onlaps the former.*

Fig. 13 - *View of Colle Foglia (CF) and Mt. Murano (MM). The dashed lines indicate the top of the Calcare Massiccio. This is overlain by a condensed succession at Colle Foglia, and by Calcari diasprigni at Mt. Murano. The two localities must have been separated by a Liassic fault - the Mt. Murano Fault (rejuvenated in Neogene times).*

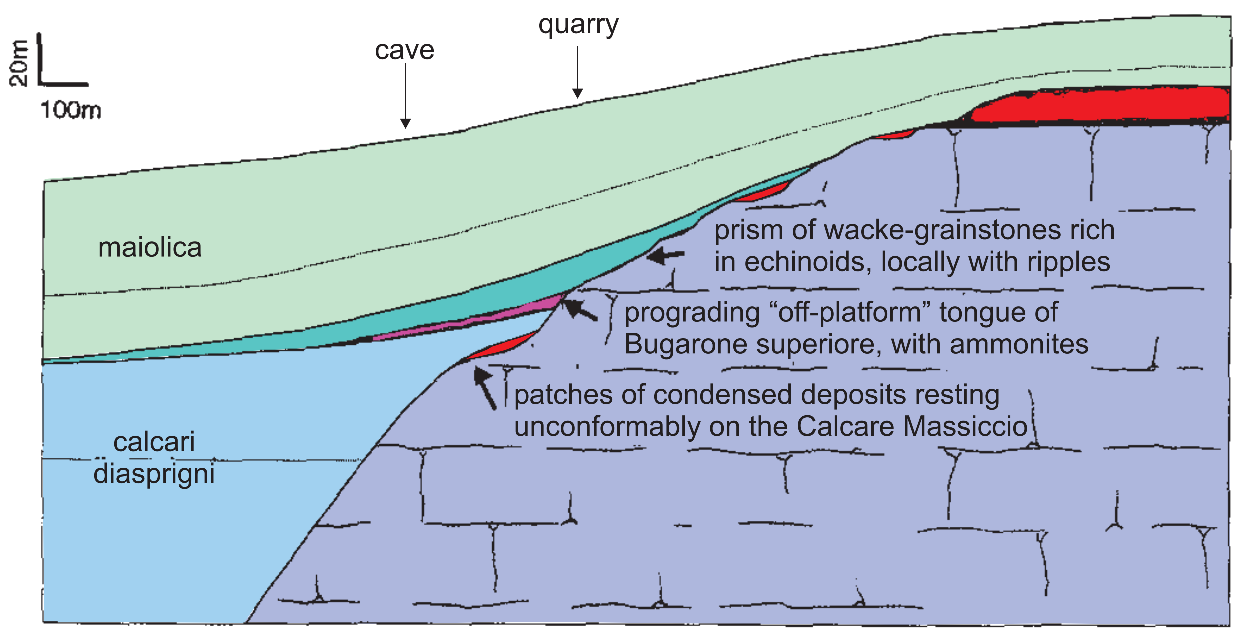


Fig. 14 - *Geometry of sedimentary bodies at the northern edge of the PCP. Note the prograding tongue of the Bugarone superiore fm., sandwiched between the Calcari diasprigni and the calcarenites rich in echinoids, that here characterise the Calcari a* Saccocoma *ed aptici.*

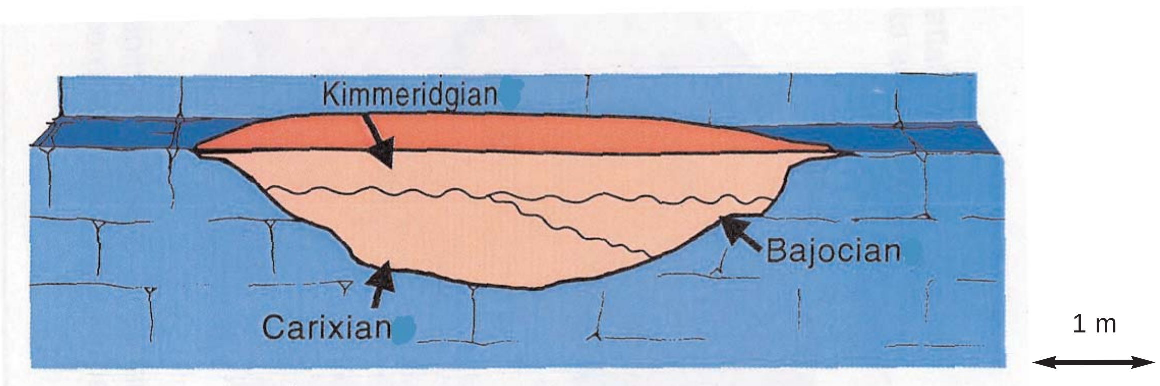


Fig. 15 - *Schematic representation of an isolated patch of the composite pelagic facies association, resting unconformably on the irregular palaeoescarpement surface, also including internal unconformities.*

nodules), have internal unconformities, and are in turn overlain by the basinal Calcari diasprigni, Calcari a *Saccocoma* ed aptici, and by the Maiolica. These patches often fill scars left by fallen blocks of Calcare Massiccio, and testify to occasional sediment preservation in a dominantly non-depositional environment. Not only do these deposits rest in marked angular unconformity on the Calcare Massiccio, but they often form very thin clones of the PCP-top succession (same formations), with frequent internal unconformities (nested unconformities) and sometimes associated lithoclasts, indicating that sedimentation alternated with non-deposition and erosion due to the ongoing morphological evolution of the margin (Fig. 15).

These condensed -often extremely fossiliferous- deposits being the physical seal to local palaeotopography, they in fact define the minimum age of a given escarpment tract, thus providing useful information on the morphological history of the platform-margin area. Because submarine palaeoescarpments in these settings correspond to fault zones of the rift stage, this can be an indication of the local palaeotectonic activity. For this reason, hunting for every patch of epi-escarpment deposits and knowing their age (commonly through use of ammonites) is a rewarding practice (Fig. 16).

A unique stratigraphic situation is seen at Mt. Murano (Fig. 17), where the Calcari diasprigni of the normal and resedimented facies association onlap the Calcare Massiccio, which is severely silicified with large chert nodules and ribbons, through a low-angle unconformity (Fig. 18).

In conclusion, while lithostratigraphy was used for mapping, facies analysis and biostratigraphy were essential tools towards understanding the complex palaeogeography and Jurassic tectonics of our study area. This integrated approach allowed to recognize four local physiographic elements (Fig. 19):

a) Pelagic carbonate platform (Colle Foglia - Colle Tordina - Mt. Sassone)

b) Basin (Valle del Vernino and Val Faedo - Val Brecciara - Vallorana)

c) Pelagic carbonate-siliceous ramp (Mt. Murano)

d) Palaeoescarpment (Valle del Vernino and Mt. Sassone to Quarry sector). We infer a minor palaeoescarpment had to separate element a) from element c), corresponding to a Jurassic fault that was reutilized in the Neogene. This is based on the occurrence of silicified Calcare Massiccio east of Colle Foglia. Decoupling of the flat-topped platform from Mt. Murano along this palaeofault allowed the northwards tilt of the latter, producing an oversteepening of the

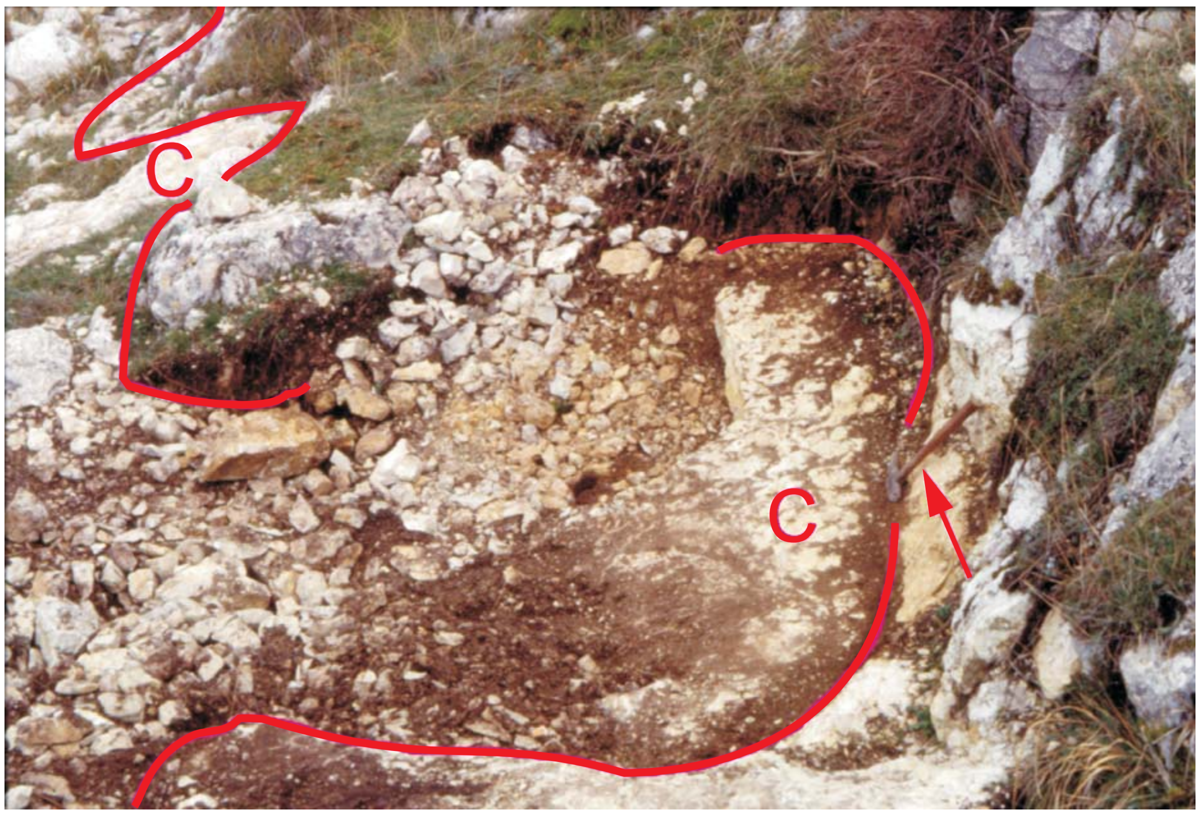


Fig. 16 - *An example of composite pelagic facies association. Condensed ammonite-rich deposits of variable ages (C) rest unconformably on an erosional surface of Calcare Massiccio (red line) at the palaeoescarpment, forming patches separated by spurs of the peritidal limestone. Basin to the left, PCP to the right of photograph. See hammer (arrow) for scale. Mt. Scoccioni, Rossa Mts. (2 km SE of the study area).*

top surface of the Calcare Massiccio, which then became non-depositional until it was buried in the Late Jurassic. These elements lost their identity in the Early Cretaceous, as the topography became regionally subdued by deposition of the Maiolica Fm.

CARTOGRAPHIC PROBLEMS AND SOLUTIONS

The main issues that had to be addressed during mapping of the area were the following:
1. Extremely reduced thickness (a few meters) and areal extent of the condensed deposits which are found on and around the PCP.
2. Various types of unconformities.
3. Occurrence of chert-bearing Calcare Massiccio, in bands parallel to unconformities rather than with stratiform geometries.
4. Mapping Jurassic faults separately from orogenic and post-orogenic faults.

The following methods were used in order to attempt to solve these problems and tackle the peculiar aspects of a small-scale PCP/basin system:
1. We chose to purposedly enlarge -albeit by as little as possible- the fields of very thin consensed formations, being aware that each represents a very long interval of geologic time, that would otherwise remain undocumented. The same was done for the smallest epi-escarpment patches, due to their exceptional geological value. The 1:10,000 scale is generally adequate for these purposes. Representation on smaller scale maps on the other hand requires grouping all the condensed formations into one higher-rank unit - a Group in fact.
2. We encountered three types of unconformities:
- *Low-angle angular unconformity*: a) the Calcare Massiccio/Calcari diasprigni onlap contact at Mt. Murano; b) the contact between the oversteepened Corniola and the overlying formations at Valle del Vernino (basin margin);
- *High-angle angular unconformity*: a) the contacts between the units of the basinal succession and the Calcare Massiccio (and/or local epi-escarpment deposits) at the palaeoescarpment; b) the base of epi-escarpment patches of condensed deposits, and the internal discontinuities separating individual pelagic formations within each patch (e.g. nested unconformities);
- *Paraconformity*: a) the base of the PCP-top condensed succession (drowning unconformity); b) the Bugarone inferiore / Bugarone superiore contact (Bathonian, Callovian and Oxfordian missing).
Each type of unconformity was assigned a separate symbol on the map and geologic cross-sections, alerting the user regarding the occurrence of peculiar geometries for these depositional systems.
3. Above we highlighted the importance of silicification at unconformable contacts with chert-bearing formations. This is one of the most typical aspects of these systems, and one which is most easily seen in the field, where it can -for example- provide evidence for an original basin-margin unconformity in places where overprinting by later tectonics is strong. In the area in question we found cherty Calcare Massiccio in three distinct areas: a) along the main high-angle contact at the basin margin at Grotta del Vernino and in the Quarry sector (NW of Mt. Sassone); b) along the low-angle ramp contact at Mt. Murano, and along the minor inferred palaeofault separating it from the PCP (Colle Foglia), (spots where silicified Calcare Massiccio was found at these areas were marked on the map with asterisks); c) an unusual, though minor, occurrence is that detected locally in correspondence of the drowning unconformity at Colle Foglia, Colle Tordina, and Mt. Sassone.
4. Jurassic faults were traced, using a separate colour, roughly parallel to the main palaeoescarpment tracts, along the vertical of the infer-

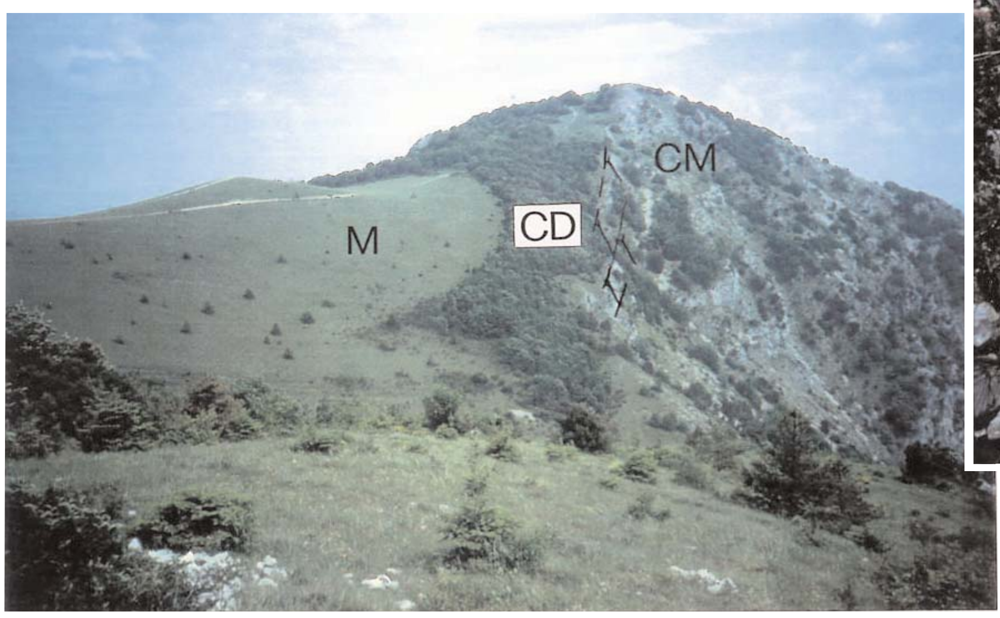


Fig. 17 - *View of Mt. Murano. The Calcari diasprigni (CD) stratigraphically follow the Calcare Massiccio (CM), which constitutes the mount summit. Their outcrop is marked by dark green vegetation, while fields roughly correspond to the Maiolica (M).*

Fig. 18 - *Mt. Murano. Cherty Calcare Massiccio near the contact with the Calcari diasprigni. Lens cap is 5 cm across.*

red (palaeo)tectonic contact between the top of the Calcare Massiccio of the hangingwall block and that of the footwall (PCP), i.e. strictly corresponding to the surface along which actual displacement is thought to have occurred. The trace of these faults does not therefore correspond to the basin-margin unconformity at the palaeoescarpment, this obviously being a stratigraphic - rather than tectonic - contact, and is mapped as a buried element "outboard" the platform. The difference between Jurassic faults and palaeoescarpments is perhaps best appreciated in geologic cross-sections.

RESULTS AND OPEN PROBLEMS

We have attempted to address various issues that are characteristic of ancient pelagic carbonate platform/basin systems with the introduction of experimental symbology. The proposed symbols serve to cover some peculiar aspects encountered in a typical mapping project in these areas, and falling in the fields of lithology and diagenesis, tectonics, and the geometry of sedimentary bodies. We believe that highlighting these particular aspects will help the map user/reader understand the key elements of a type of depositional system which may not have present-day analogs, but which is widely -though not solely- found in rocks ranging from the Cambrian to the Cretaceous. At the same time we have tried to keep things relatively simple and readable, as a geological map should be. Problems remain regarding the scale of mapping, 1:10,000 being the best format for the use of our symbols, and this being still sometimes barely sufficient to represent certain features. Use of smaller scales certainly requires extended use of points ymbols, such as asterisks, rather that areal or linear symbols.

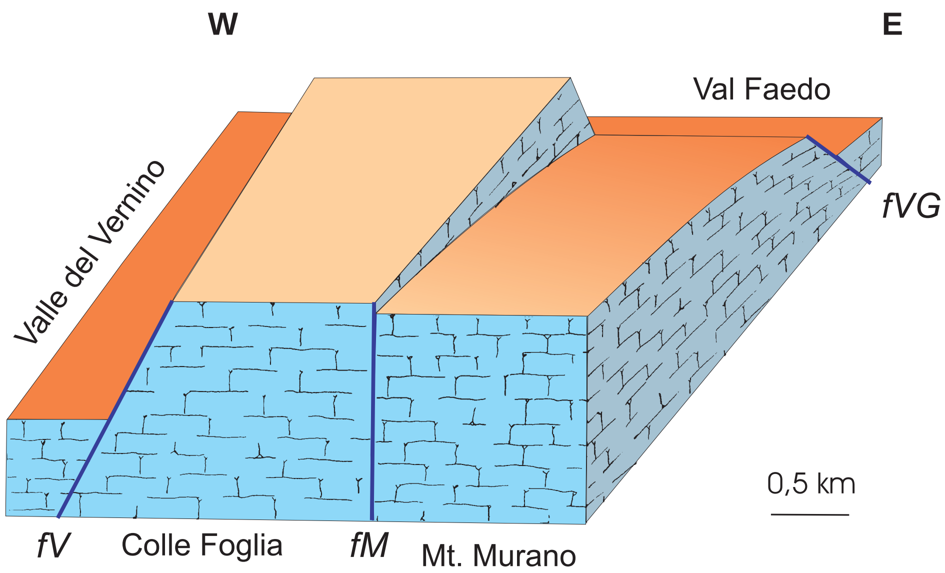


Fig. 19 - *Qualitative block diagram showing the inferred Jurassic structure of the study area. Post-Calcare Massiccio deposits have been stripped. The PCP has a deeper basin to the west and north, and the rotated Mt. Murano block to the east. fV Vernino fault; fVG Valle della Grotta fault; fM - Murano fault, depicted as a vertical surface only due to the lack of evidence concerning its dip.*

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