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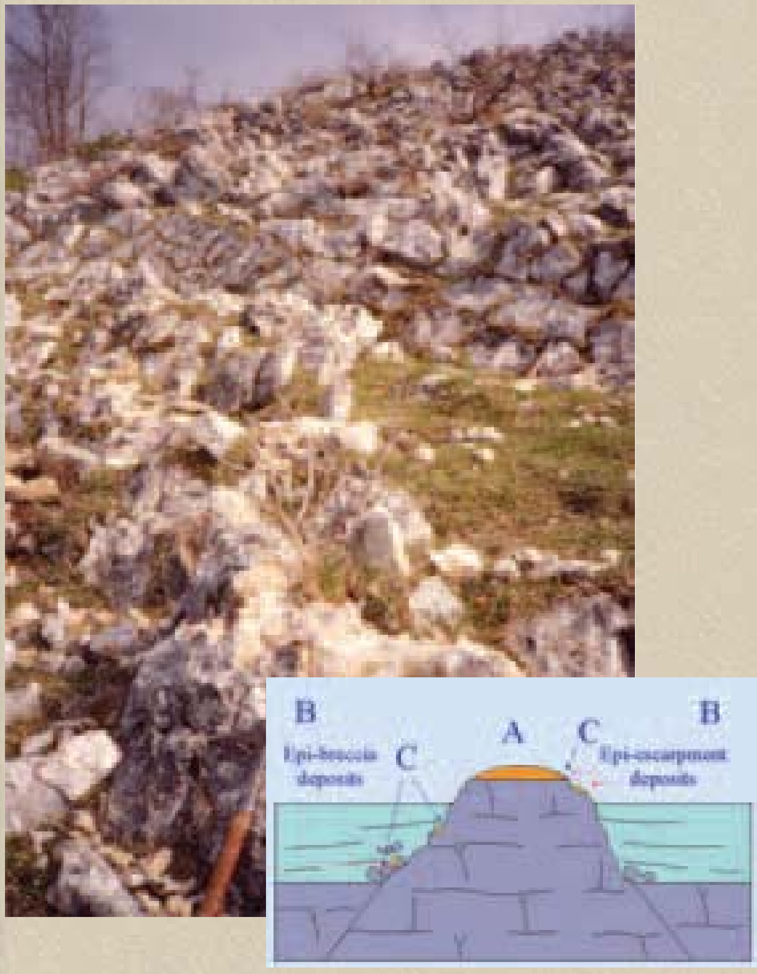
FACIES AND GEOMETRIES OF PELAGIC DEPOSITS IN A JURASSIC PELAGIC CARBONATE PLATFORM / BASIN SYSTEM - SABINA, CENTRAL APENNINES (ITALY)



Leader: M. Santantonio

Florence - Italy
August 20-28, 2004

Post-Congress **P49**

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FACIES AND GEOMETRIES OF PELAGIC DEPOSITS IN A JURASSIC PELAGIC CARBONATE PLATFORM / BASIN SYSTEM - SABINA, CENTRAL APENNINES (ITALY)

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Front Cover:
Large ammonite in Upper Jurassic condensed deposits at the top of the Sabina Plateau. Below: distribution of the facies associations in a pelagic carbonate platform/basin system (see text)

Leader: M. Santantonio

Introduction

This field trip serves to illustrate some aspects of the peculiar Jurassic geology of the Sabina region. Formerly interpreted as an homogeneous platform-to-basin transitional slope linking the Latium-Abruzzi Platform to the Umbria-Marche domain, the area has recently undergone some substantial reinterpretation (SANTANTONIO & GALLUZZO, 1996; GALLUZZO & SANTANTONIO, 2002) (Fig. 1).

While the general view of the typical Sabina basinal facies, as characterized by varying amounts of resedimented material of shallow water origin remains confirmed, the discovery of a huge Jurassic intrabasinal high, named the "Sabina Plateau", and bounding the Sabina Basin *s.s.* to the west, must change our views on the region. The Jurassic Sabina Basin can in fact be redefined as a basin locked to the east and west by the Latium-Abruzzi Platform and the Sabina Plateau, respectively. Also, the basin hosts in turn lower-rank highs, as seen in the Reatini Mts. (CHIOCCHINI *et alii*, 1975; LEONARDI *et alii*, 1997), most of which became buried as early as in the Middle Jurassic (the Sabina Plateau persisted instead until the Early Cretaceous).

What makes Sabina stand apart from neighbouring regions, such as the Umbria-Marche, with which it shares essentially the same pelagic stratigraphy, are therefore essentially two features:

1. The larger size of palaeostructural elements, such as the Sabina Plateau, that is also accomplished by a greater amount of vertical offset along master palaeofaults. This has also resulted in much greater accommodation space available for basinal successions.
2. The strongly resedimented nature of basinal successions.

Regional geologic setting

The Jurassic history of the Sabina and Umbria-Marche Apennines in central Italy starts with the development of a carbonate megabank, occupying most of today's peninsular Italy, represented by the Hettangian - Sinemurian Calcare Massiccio Fm. This rests on an Upper Triassic succession, overlying a deformed Hercynian substrate, and is made of evaporites (Anidriti di Burano Fm.), and shallow shelf carbonates (*Rhaetavicula contorta* beds) (PASSERI, 1975). Extension may have already been active during the deposition of the Calcare Massiccio, with high sedimentation rates compensating for the differential subsidence, and preventing the formation of morphological basins (ALVAREZ, 1989). Still, syndepositional extensional features, such as shallow listric growth faults, have never been positively documented in this formation. Extensional tectonics, by contrast, did display their full destructive potential in the Sinemurian. This gave rise to a complex submarine topography with structural highs and intervening basins, which would produce the gross Jurassic stratigraphic pattern of the region, with spectacular lateral changes of facies and thickness (see below) (COLACICCHI & PIALLI, 1967; FARINACCI, 1967; BERNOULLI, 1971). The deeper-water sequence found in basins is underlain by a peculiar unit, named the "Calcare Massiccio C" by CENTAMORE *et alii* (1971), and is mostly made of onkolite/bioclast-rich packstones with admixed sponge spicules and radiolarians, representing the start of the tectonically-induced foundering and drowning of the platform. Following this, a thick pelagic and resedimented succession slowly buried the submarine rift topography. By contrast, structural highs managed to survive for some millions of years as productive, though relatively unhealthy, isolated platforms. These hosted a peculiar subtidal facies known as Calcare Massiccio B, where typical shallow-water elements, such as coated grains, peloids, and an assorted micro- and macrofauna, are set in a micritic matrix with sponge spicules, radiolarians, and very rare ammonites (CENTAMORE *et alii*, 1971; BICE & STEWART, 1990). This clearly documents how dramatically-altered sea-water circulation around them affected these isolated highs, formerly sheltered areas within a vast intertidal flat, putting the carbonate factory under stress while it was still in shallow water. In the Pliensbachian (Middle Carixian *Tragophylloceras ibex* Zone), these fault-bounded platforms were finally drowned, probably due to a non-tectonic palaeoceanographic eutrophication event, and turned into pelagic carbonate platforms (PCP) (SANTANTONIO, 1993, 1994; SANTANTONIO *et alii*, 1996; see MORETTINI *et alii*, 2002, for a geochemical perspective on the subject). Slow and discontinuous pelagic sedimentation took place over them in a post-rift regime, until basin-filling was completed in Earliest Cretaceous times and submarine topography was leveled by the Maiolica Fm.

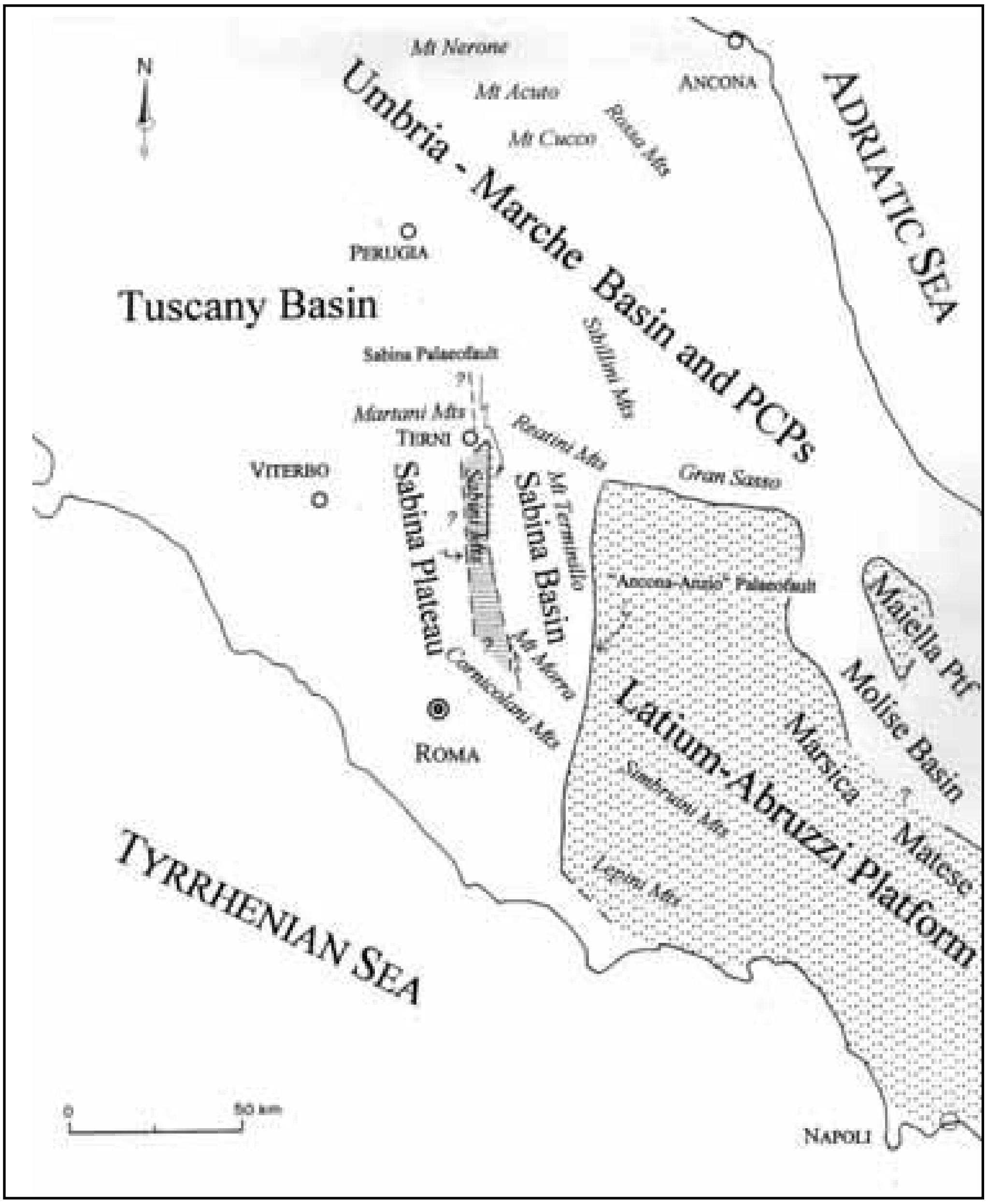

Figure. 1 - Simplified Middle Jurassic palaeogeography of central Italy, with inferred extent of the Sabina Plateau.

Facies associations

In pelagic carbonate platform/basin systems, facies associations are strongly tied to sea-bottom palaeotopography, in turn largely the product – at least initially - of rift tectonics.

Three associations have been identified by SANTANTONIO (1993) (Fig. 2):

A. The condensed pelagic facies association. This is typical of PCPs, and is made up of condensed pelagic deposits, resting in geometrical concordance above the drowned Calcare Massiccio. These deposits are characteristically richly ammonitiferous, and are devoid of chert, and of any kind (see stop description for an exception) of gravity flow deposits. The

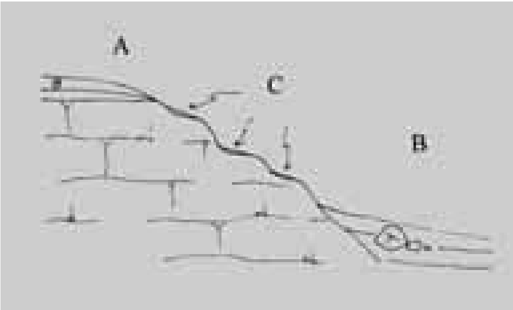

Figure 2 - Facies associations A, B and C, and erosional PCP margin

general geometry of these deposits on PCPs is that of a convex-up lens, with drastic thinning towards the edges, where the most discontinuous and most fossiliferous sections are found ("panettone" geometry). This duplicates the seamount-top geometry of pelagic deposits described by Winterer (1991) in the Allison Guyot Mt. in the Pacific (Fig. 3), and is probably due to the combined effects of submarine erosion, and the different angle of repose

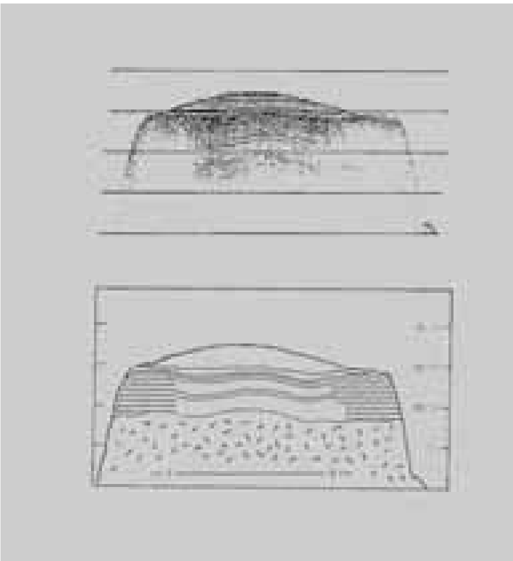

Figure 3 - Seismic reflection profile of Allison Guyot in the Mid-Pacific Mountains. The reefal sediments comprise two seismic facies, a perimeter reef without coherent internal reflectors, and a central lagoon with continuous reflectors. Volcanic basement is inferred to be a depth of about 600 m (2-way reflection time). The reefal sediments are overlain across an unconformity, showing karstic relief by a mound of post-Cenomanian pelagic sediments, shaped by mid-water currents (after Winterer, 1991).

of pelagic mud with respect to the underlying lithified peritidal limestone. A striking regional feature of PCP-top deposits, and one having a strong impact on regional subsidence history, is that of bearing pennular thamnasteriid corals in the Tithonian, interpreted as deep-photic forms by Lathuiliere & Gill (1995), Insalaco (1996), Santantonio *et alii* (1996), and Gill *et alii* (in press). Another important feature in the Sabina and Umbria-Marche regions, is the occurrence of a hiatus spanning the Late Bajocian to the earliest Kimmeridgian (Cecca *et alii*, 1990). Typical thickness figures for Carixian to Tithonian PCP successions are about 40 m.

B. The "normal" and resedimented pelagic facies association. This is found in basins, and is represented by pelagic deposits derived from the perennial fallout of planktonic organisms, by peri-platform ooze, by admixed terrigenous clays, and by various deposits of gravity flow origin. Basin-margin deposits often host megabreccia wedges and isolated olistoliths produced by the collapse of marginal PCP escarpments. This is most notable in the lower part of the Lower-Middle Liassic Corniola Fm., representing syn-rift sedimentation. The thickness of Jurassic basin-fill deposits varies from ~500 m in the Umbria-Marche to ~1500 m in the Sabina area.

C. The composite pelagic facies association. This typically represents epi-escarpment sedimentation and is made of condensed cephalopod-rich deposits, often identical to their PCP-top counterparts, resting through an angular unconformity above the peritidal limestone (or on older PCP deposits in the uppermost escarpment). On palaeoescarpments, sedimentation could only occur wherever meso-topography permitted, as in block-detachment scars, often in sites where the equilibrium with erosion was unstable. Due to the odds of preservation, and to periodic collapses, epi-escarpment deposits form scattered patches of contrasting age along the escarpment profile. Their thickness ranges from a thin veneer to a bed succession that mimics part of the PCP-top succession, and these deposits are ponded in larger morphological lows and are commonly sites of nested unconformities. Due to their peculiar palaeosetting, epi-escarpment deposits often form a sedimentologically unusual mixture of condensed sediment and lithoclasts (derived from the erosion of higher parts of the local escarpment). The composite pelagic facies association was at home on any substrate that was elevated with respect to the basin bottom, so it also developed on megabreccias, and larger olistoliths, until they became buried by basinal deposits.

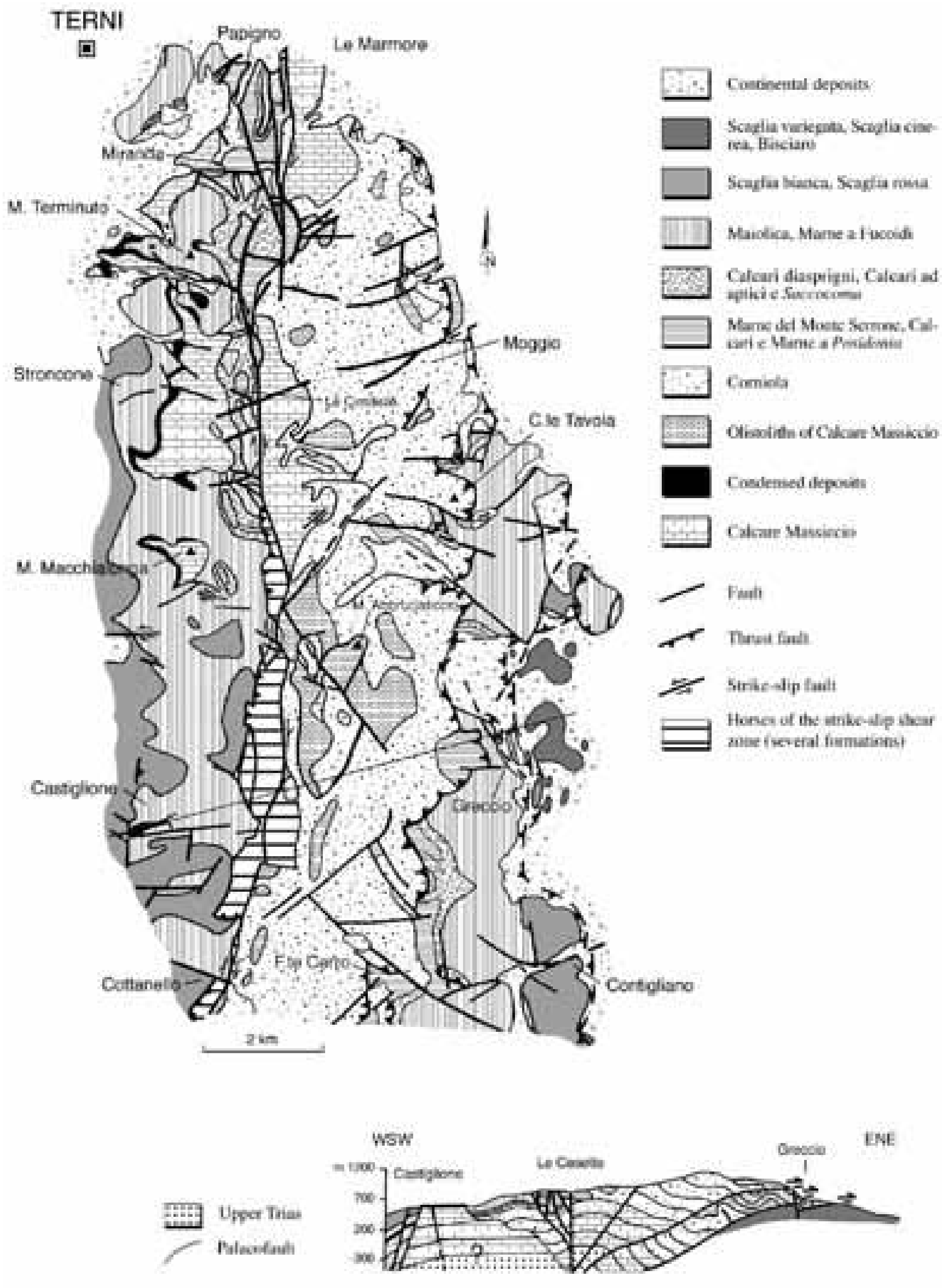

Figure 4 - Geological map of the Sabini Mts, between the parallels of Terni and Condigliano (After GALLUZZO & SANTANTONIO, 2002).

Geology of the Sabini Mountains

The Sabini Mts. form a N-S elongated mountain range that is bounded to the north, south, and east by Quaternary continental deposits of the Terni Plain, the Tiber Valley, and the Rieti Plain, respectively. To the northwest they are instead separated from the NW-SE trending Narni-Amelia range by a syncline mostly made up of Neogene flysch deposits (fig. 4).

Galluzzo & Santantonio (2002, and bibliography therein) describe the following main structures (see also Cosentino *et alii*, 1992), from east to west. 1. A frontal thrust, with superposition of Mesozoic carbonates on Tertiary carbonate and terrigenous deposits. 2. A more internal thrust within the Mesozoic carbonates, having Jurassic deposits at the top ,and often forming a footwall flat in the Toarcian Marne di Monte Serrone Fm.. 3. The dextral strike-slip "Sabina Fault" (Alfonsi *et alii*, 1991a, b), with associated (mainly) positive flower structures in the form of west-verging reverse faults. 4. The Jurassic Sabina Palaeofault east-dipping escarpment, with the Sabina Plateau to the west.

Numerous Quaternary normal faults, many having an E-W strike, cut these structures, and the western side of the Sabini Mts. is overall marked by west-dipping normal faults.

Jurassic to Lower Cretaceous stratigraphy of the Sabina Plateau

On the Sabina Plateau, a condensed and discontinuous Pliensbachian to Tithonian/Lower Berriasian pelagic succession rests in geometrical concordance on the peritidal limestone (Fig. 5). Younger formations are also very thin, but do not have a condensed appearance, and generally have a facies similar to that of basinal successions, as a result of basin filling. The Jurassic pelagic succession is not more than 40 m thick, but locally even thinner, and is found along a north-south alignment of outcrops in three main areas: 1. The Stroncone area; 2) the western slopes of Mt. Macchialunga; 3) the Castiglione di Cottanello area (Fig. 4). Surprisingly enough, only the third area has received some attention from geologists in the past years (Maxia, 1951; Farinacci, 1967; Cecca & Santantonio, 1982; Cecca *et alii*, 1985).

- The Jurassic succession starts with the Calcare Massiccio, a unit built by pure peritidal carbonates, locally organized into evident shallowing-upwards cycles, and bearing numerous subaerial exposure surfaces. The observable thickness amounts to about 0.8 km, but the base is not exposed. The age is

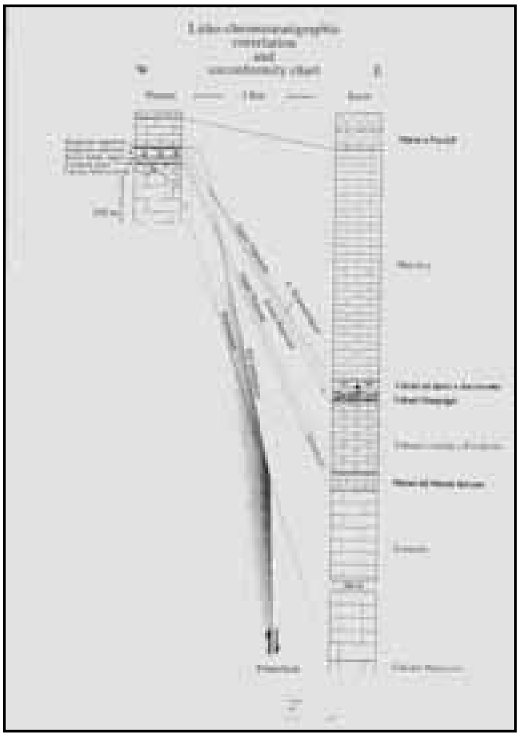

Figure 5 - Time-stratigraphic correlation of the Sabina Plateau and Sabina Basin. Turbidites and olistholiths are not graphically represented in the basinal log. This is also an unconformity chart, showing that in pre-Maiolica times, all basinal units are physically unconnected with the plateau units, and the Maiolica is the only one that also onlaps the plateau units, eventually becoming connected to its plateau-top equivalent.

Hettangian - Sinemurian.

- The next unit is the Calcare Massiccio "B", *sensu* Centamore *et alii* (1971) (= Corniola Massiccia in Passeri, 1971). It is typically made of white wacke- to grainstones, with coated grains (including small oncolites and lumps), peloids, and often a mud matrix with sponge spicules. Crinoids and benthic forams [including *Agerina martana* (Farinacci)] are characteristic, with rarer calcareous sponges and small ammonites. This unit does not occur all across the plateau, and can rest unconformably on the previous one. It reaches about 60 m in the Stroncone area (Rio il Fossato), and seems to gradually thin out towards the south: it is 25 m thick near Croce Micciola (Mt. Macchialunga), and virtually disappears in the Castiglione area, where it is replaced by a drowning unconformity. This wedge geometry is interpreted as the result of a northwards tilt of the plateau. Its age is not well known, but its stratigraphic position indicates this unit must have been deposited in the Lotharingian - Carixian *p.p.*.

- The Corniola-equivalent Fm. (*sensu* GALLUZZO & SANTANTONIO, 1994) (= “Calcari Stratificati Grigi” in CENTAMORE *et alii*, 1971), is a condensed pelagic wackestone, light brown in colour, with hardgrounds (west of Mt. Macchialunga). It contains a fauna dominated by cephalopods, brachiopods, and crinoids, but calcareous sponges (including sphinctozoans), also occur. Quite unlike other condensed successions in the Umbria-Marche, this unit is completely missing or is extremely thin in most localities (Castiglione). The thickest section is about 7 m thick. The ammonite ages detected are Carixian and, more frequently, Domerian.
- The Rosso Ammonitico-equivalent Fm. (*sensu* GALLUZZO & SANTANTONIO, 1994) (= “Calcari Nodulari e Marne Verdi” in CENTAMORE *et alii*, 1971), is made of red-to-brown nodular marly limestones and red marls. Despite its name, ammonites are uncommon, and other fossils are also rare in this unit, with the exception of posidoniid bivalves. The thickness varies greatly: a maximum of 16m has been measured in the Castiglione quarry (FARINACCI, 1967), but 0.7 km to the east it is reduced to 7-8 m, which is the average for the plateau. Much thinner sections also exist locally. The age of this formation is Toarcian *p.p.*.- The Bugarone inferiore Fm. (CECCA *et alii*, 1990) (= “Calcari Nodulari Nocciola” in CENTAMORE *et alii*, 1971) consists of light brown mud- to packstones, locally marly and nodular, and dolomitized in places. Posidoniid bivalves characterize this unit, which attains a maximum thickness of ~20 m. Ammonites are sparse, but can be relatively more common in the lowest and uppermost parts. The upper part of the unit contains characteristic protoglobigerinids. The age of this formation is Toarcian *p.p.* to Lower Bajocian.
- The Bugarone superiore Fm. (CECCA *et alii*, 1990) (= “Micriti a Cefalopodi” in CENTAMORE *et alii*, 1971) is made of light grey to light brown/green fossiliferous wackestones, with an exceptionally rich cephalopod local fauna (ammonites, aptychi, belemnites, rhyncholites), allowing for a very high-resolution biostratigraphic control (CECCA & SANTANTONIO, 1982; CECCA *et alii*, 1985). Bivalves (lower part), brachiopods (*Pygope* sp.), crinoids, and solitary and colonial corals, mostly pennular (GILL, 1967; SANTANTONIO *et alii*, 1996, and bibliography therein), are also present. Rare sphinctozoan sponges occur in the Kimmeridgian. The lower part still bears protoglobigerinids, but no more posidoniids. The total thickness is extremely variable, and usually ranges from 2 m to about 11 m. Its age is Early Kimmeridgian to Late Tithonian/Berriasian.

The Bugarone superiore rests on the Bugarone inferiore *via* a paraconformity, with a hiatus of about 20 million years (see above).

- Maiolica Fm. This is a white, thinly bedded mudstone, mostly cherty (with the exception of the basal 5-10 m) and locally with thick dolomitic intervals (Castiglione ~17 m). An abrupt fall in macrofossil occurrence is typical for the unit, which contains biostratigraphically useful calpionellids in the lower part, and sparse aptychi. The basal levels at Castiglione bear sparse colonies of pennular corals (Lower Berriasian, “B Zone” – F. CECCA, pers. comm.). The thickness ranges from 58 m (Castiglione) to more than 170 m (near Stroncone). The age is Berriasian *p.p.* - Early Aptian.

Jurassic to Lower Cretaceous Stratigraphy of the Sabina Basin

(western part)

East of the Papigno - Cottanello meridian alignment, the coeval stratigraphic successions are radically different from those of the plateau (Fig. 5). Besides being much thicker, differences also affect their lithostratigraphy, facies, and geometries.

- Corniola Fm. This is the oldest and thickest basinal unit (> 1 km) found in our study area. It is made of white to light brown, to dark grey pelagic cherty mudstone, with abundant graded and laminated beds (up to several meters thick), slumps, and breccias. Grey shale interbeds are found in the upper part. Resedimented deposits, totalling several hundred meters in thickness, mostly consist of shallow-water sands, with ooids and bioclasts (molluscs, echinoderms etc.), often with a finer tail with pelagic components. They are most abundant in the lower part of the unit. Background pelagic deposits bear radiolarians, benthic forams, and sponge spicules. The unit characteristically contains megabreccias and huge (up to >1 km across) isolated olistoliths of Calcare Massiccio, which partly account for the abnormal thickness of the unit as derived from geologic cross-sections. The olistoliths are more common towards the west, that is closest to the plateau. Ammonites are extremely rare, but the Corniola is regionally well known to span the Sinemurian through the earliest Toarcian.
- Marne del Monte Serrone Fm. These are grey to greenish marls and shales, with interbedded brown calcarenites bearing rare light brown chert nodules.

Less than 1 m above the base, a thin (0.4-0.5 m) black shale interval, with plant and fish remains, marks one of the oceanic anoxic events of JENKYNS (1985) (Lower Toarcian, *Dactylioceras tenuicostatum* Zone). The interbedded calcarenites, in beds generally 10-30 cm thick, are usually graded and laminated with spectacular Bouma sequences, locally with small scale (wavelength 20-50 cm) hummocky cross stratification (MONACO, 1992). They contain fine detritus, mostly of unidentified origin, but posidoniid bivalves are present, and ooids and other shallow water material are visible in coarser-grained levels. The Marne del Monte Serrone locally bear olistoliths of Calcare Massiccio. Red nodular marls and shales, also with posidoniids, up to 6-7 m thick and similar to the typical Rosso Ammonitico of Umbria and Marche, are often found at the top of the unit. The total thickness averages 30 m. The age is Toarcian *p.p.*

- Calcari e Marne a *Posidonia* Fm. The base of the unit is marked by a sharp increase in carbonate content, and by the appearance of conspicuous chert. This formation is made of light-coloured cherty pelagic mudstone, and is more marly near the base (where it is pinkish and has shaly interbeds) and more cherty towards the top. Macrofossils are extremely rare, with the exception of the lower part, which bears occasional ammonites (*Tmetoceras* sp., Aalenian) and belemnites. Distinctive constituents are posidoniid bivalves: they often occur in lithogenic quantities, with laminated shell accumulations being more common in the upper cherty portion. Resedimented levels can be locally dominant, with thick packages of graded beds bearing shallow water material (ooids, bioclasts, etc.), often with a laminated top with posidoniids. Olistoliths and breccias are rare in the lower part, but huge isolated blocks appear upsection, and a megabreccia occurs at Castiglione (see stops). The transition to the next unit is gradual, and is represented by an upper member of bedded cherts with little carbonate, but still with posidoniids. The thickness is 60-150 m. The age is latest Toarcian to ?Early - Late Bajocian (BARTOLINI *et alii*, 1996).

- Calcari Diasprigni Fm. This formation consists of radiolarian cherts and subordinate cherty limestone in thin tabular to pinch-and-swell beds, green-to brown-to-red in colour, with mm-thick shale interbeds. Most characteristic of the unit is the virtually absolute lack of macrofossils, while the microfauna is dominated by radiolarians. Also typical is the absence of resedimented levels of shallow water origin, with the exception of the Contigliano area. The Calcari Diasprigni can bear huge (longer axes up to 0.8 km) olistoliths of Calcare Massiccio, but some of them are actually shared with the units below and above: *i.e.* certain blocks fell into the upper levels of the Calcari e Marne a *Posidonia*, and became progressively buried by the next two formations. The total thickness of the Calcari Diasprigni is 20-60 m, the thinnest sections being found in the westernmost part of the basin. Following CECCA *et alii* (1990), we use this unit name in a restrictive sense, therefore excluding both those cherts and cherty limestone that still bear posidoniids, which we place in the previous unit, and the younger cherty levels with *Saccocoma*, that are accommodated in the next unit. The age of the Calcari Diasprigni is based on radiolarian stratigraphy (BAUMGARTNER, 1987; BARTOLINI *et alii*, 1996), and on faunas collected below and above them. Figures may vary in the literature also depending on the choice of lower and upper formation boundaries. The age of this unit - as we defined it above - should encompass the ?Late Bajocian/Bathonian through the Early Kimmeridgian.

- Calcari ad aptici e *Saccocoma* Fm. This is a calcareous/marly/cherty unit with strong lateral variability. Lithology and texture range from pale radiolarian-rich cherty mudstones, with only sparse *Saccocoma* ossicles, to dark red fossiliferous (aptychi, belemnites, rare ammonites etc.) nodular marls, to grey/pink graded and laminated crinoidal sands, locally well sorted, and thoroughly silicified. The latter two facies are best developed closer to the plateau, while muddier facies are found more to the east. Sections close to the plateau have bed packages, decimeters to 5 m thick, with intercalations of the Bugarone superiore Fm., in the form of pale-coloured homogeneous to nodular wackestone, with Tithonian cephalopods, bivalves, gastropods, brachiopods, and crinoids ("off-platform tongues" of SANTANTONIO *et alii*, 1996). The average thickness is about 20 m, but up to 45 m thick sections are known in the region. The age is Kimmeridgian *p.p.* - Tithonian.

- Maiolica Fm. The unit is almost entirely made up of thinly-bedded white cherty radiolarian mudstone, with only sparse macrofauna (cephalopods) and calpionellids in the lower part. Resedimented levels of shallow water origin are virtually missing, but evidence of submarine sliding of pelagic mud is provided by common slumps. The base is marked by the disappearance of *Saccocoma*, while the top is placed above the last black chert bed, and can locally bear thin black shales. The Maiolica has a maximum thickness of about 0.5 km. Its age is Tithonian/Berriasian to Earliest Aptian.

Field itinerary

DAY 1

STOPS 1.1 – 1.4 – Facies and geometries of plateau-top, plateau-edge and marginal basin deposits at Castiglione

Stop 1.1: The condensed succession near the plateau edge (see above for a general description of individual formations – only local features will be mentioned).

The thin Jurassic succession at Castiglione was described by MAXIA (1948, 1951, 1952), and by FARINACCI (1967). CECCA & SANTANTONIO (1982) and CECCA *et alii* (1985) described the composition and biostratigraphy of the Kimmeridgian - Tithonian ammonite fauna, and Castiglione is the locality where the Bajocian/Kimmeridgian hiatus was first described and defined with a resolution down to the ammonite-zone level. The paper by FARINACCI (1967), in particular, contains several useful sedimentological and geometrical observations. Most notably, she described the erosional morphology of the local palaeoescarpment tract and the thickening to the west of the condensed succession. However, her interpretation of subaerial exposure features within the pelagic succession, and the Oxfordian age she inferred for the Rosso Ammonitico, cannot be confirmed at present.

A thin Liassic to Lower Cretaceous succession is exposed for 0.7 km along the southern slopes of the hill where the now abandoned village of Castiglione was built.

The uppermost meters of the Calcare Massiccio bear traces of repeated subaerial exposures, such as reddened surfaces and irregular cavities infilled with brown barren mud, and the top surface of the unit is locally irregular, so it is conceivable that a phase of emersion predated its drowning (more on this below). This could have been related to an isostatic uplift of the footwall (JACKSON & MACKENZIE, 1983), coincident with the phase of severe extension, that in turn gave birth in the Sinemurian to the Sabina Palaeofault, and the Sabina Basin to the east.

The Calcare Massiccio B. is either missing or is sometimes seen to fill in small pockets at the top of the Calcare Massiccio.

The Corniola-equivalent Fm., representing the lowest bed of the condensed pelagic facies association, is also either missing or it occurs patchily, with a maximum observable thickness of few decimeters. Nevertheless, two main facies can be recognized:

1. Bioclastic wackestones with ammonites (*Emaciaticeras* sp. - Domerian *p.p.*);
2. Mudstones with ostracods and rare ammonites, in thin alternating red and yellow-green cm-thick bands, locally separated by isopachous calcite cement crusts.

The latter facies is especially intriguing. The yellow mudstone is inhomogeneous, but not in the way bioturbation might, for example, have produced it, nor is any obvious sedimentary structure visible. Rather, cm-size undulations seem to define small lithons, thus seemingly representing a secondary modification of the original homogeneous sediment through some sort of stress and/or plastic flow. This mudstone must then have been sliced into thin sheets, creating stacked laminar cavities that were enlarged and filled with younger silt to mud-sized red sediment, and resembling bedding-parallel neptunian dykes, connected by high-angle fissures (GIOVAGNOLI, 1981). This sediment is sometimes graded and contains internal discontinuities. Also, the cavities remained locally partially empty, forming geopetal structures–all this suggesting that the infilling was discontinuous and difficult. On top of this, the yellow-green laminites are often crinkled and folded and have small internal thrusts.

This mix of extensional and contractional geometries, associated with the above described features, and confined to this particular stratigraphic level, is strongly suggestive of creeping and detachment along the top of the Calcare Massiccio, which might have occurred even along a very gentle slope, under the burden of at least the Rosso Ammonitico-equivalent, which provided the infilling material. Analogous sheet cracks received a similar interpretation by TUCKER (1974) in a Palaeozoic condensed succession and by KENDALL (1985) in an ancient forereef.

The Rosso Ammonitico-equivalent overlies in geometrical concordance either the Corniola-equivalent or the Calcare Massiccio, in the latter case marking a drowning unconformity (SCHLAGER, 1989). Its thickness here is ~9 m, but it reaches 16 m less than 1 km to the west, and can be either deep red or yellow, with a distinctive “onion-like” exfoliation.

The Bugarone inferiore is consistently 19 to 21.5 m thick throughout the area. Near the base it yielded latest Toarcian *Catulloceras* sp., while the top has stephanoceratid faunas indicating the Lower Bajocian *Stephanoceras humphriesianum* Zone.

A paraconformable contact marks the base of the Bugarone superiore. This unit is 1.9 m thick here, but thickens westwards to about 6 m. The Kimmeridgian is locally as thin as 37 cm, and provides one of the most outstanding ammonite assemblages of its age in the Apennines. The lowest forms indicate the *Crussoliceras divisum* Zone, largely dominated by representatives of *Nebrodites.* The top 8 cm represent the *Hybonoticeras beckeri* Zone, with dominant *Taramelliceras (T.) pugiloides* (Canavari), *Hemihaploceras (H.) nobile* (Neumayr), *Pseudowaagenia acanthomphala* (Zittel), *Hybonoticeras pressulum* (Neumayr), and assorted perisphinctids. In between is an assemblage with *Nebrodites (Mesosimoceras) ludovicii* (Meneghini), that might either still belong to the *C. divisum* Zone or represent the *Taramelliceras compsum* Zone of Oloriz (1978). We are therefore dealing with a discontinuous succession, where bedding planes are erosional surfaces truncating the ammonites, and representing diastems. A large (approx. 40 cm in diameter by 30 cm in height) cerioid coral colony, collected in the Kimmeridgian by U. Nicosia, was illustrated in Galluzzo & Santantonio (2002). This has recently been identified as a new taxon (*Castiglionastrea tenuisepta* nov. gen. nov. sp.) by Gill *et alii* (in press). The Tithonian is also ammonitiferous, but ammonite biostratigraphy is less practicable. A basal bed (60 cm) bears a mixed assemblage representing the *Hybonoticeras hybonotum* to *Semiformiceras semiforme* Zones, and also contains thin encrusting thamnasteriid colonies of microsolenid pennular corals in the upper part (see Santantonio *et alii*, 1996, and bibliography therein, for an extensive discussion). The condensed ammonitiferous facies, typical of the Bugarone superiore, also continues into the Upper Tithonian and the Lower Berriasian, where it still bears occasional pennular corals in a typical Maiolica-like matrix, with *Calpionella alpina* (*Berriasella jacobi* Zone, F. Cecca pers. comm.) (see also Cecca, 1985).

The Maiolica is 58 m thick, and is dolomitic from 3 to 20 m.. Chert appears at 8.5 m from the base.

Stop 1.2:

Geometries and lateral variability of the Bugarone superiore, and oolite-rich lenses in the upper beds of the Bugarone inferiore

Less than 20 m to the west of the previous stop, the Bugarone superiore displays some peculiar local geometries. The Kimmeridgian here is a lens that is 60-80 cm thick and, besides being thicker, it bears a more complete biostratigraphic record with the *Mesosimoceras cavouri* Zone, which was missing in the previous section. Also, the *H. beckeri* Zone here is 15 cm thick (Fig. 6). Above it, the geometry of the lowest Tithonian bed is that of a prominent wedge that changes from 70 to 10 cm eastwards, over a distance of a mere couple of meters (Fig. 7).

These features are taken as evidence of the mounded geometry, with drastic thin-out towards the edge (lying to the east, as we shall see), of the plateau-top condensed sedimentary cover.

Below the Bugarone superiore, the highest beds of the Bugarone inferiore are more richly ammonitiferous than the rest of the unit. Two discontinuous lens-like levels occur in its top 3-4 meters, and these have some intriguing features.

Their maximum thickness is 30 cm, and this is achieved wherever their base is a concave scour. They are normally graded and parallel to cross-laminated, and are made of a mixed posidoniid/oolite sediment, with added mud chips of the host formation (Fig. 8). In thin section, oolites are seen to belong to the “well-rounded micritic ooids with thinly-laminated cortices” and the “ooids with thinly-laminated fine-radial cortices” types of Strasser (1986) (Fig. 9). So we can conclude they are typical shallow-water oolites.

This occurrence is quite unexpected, because no trace of a peritidal platform environment can anywhere be documented in the Bugarone inferiore to be found in the plateau, thus the ooids must have been displaced. However, they are found on a prominent morpho-structural high, so a gravity flow origin should theoretically be ruled out. This should not be ruled out here, however, because their occurrence can indeed be best explained as the result of the overbanking of a turbidity flow, travelling across the Sabina Basin, and

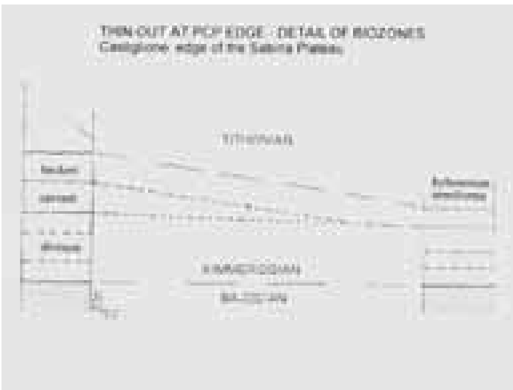

Figure 6 - Ammonite biozonal correlations, showing the disappearance of units towards the east (plateau edge) at Castiglione. Note horizontal scale.

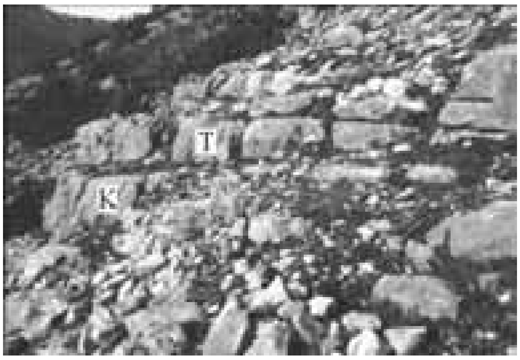

Figure 7 - Lower Tithonian bed of Bugarone superiore (T) wedging out towards the Plateau edge (east), and resting on the Kimmeridgian (K). Castiglione, condensed succession.

finally impacting the huge obstacle represented by the marginal palaeoescarpment of the plateau (Galluzzo & Santantonio, 2002). Oolite-rich turbidites coming from the Latium-Abruzzi Platform, sometimes in very thick beds, abound in the basinal equivalent of the Bugarone inferiore, the Calcari e Marne a *Posidonia*. Moreover, these resedimented beds are commonly found onlapping the palaeoescarpment, so the crashing of turbidity flows against submarine outcrops of Calcare Massiccio must have been common.

Given the estimated submarine relief at the time, amounting to no more than 250-350 m, the possibility for a turbidity flow, that is commonly tens to even hundreds of meters thick within the water column, to run up the plateau flanks and sweep its top, was fully feasible (Kneller & Buckee, 2000) (Fig. 10).

We shall resume this discussion on the occurrence of ooids below, as we shall see that they are also found elsewhere in the area.

Figure 8 - Parallel- to cross-laminated (arrow) posidoniid-rich pack-to wackestone, also with oolites, interpreted as overbank deposits. Bugarone inferiore. Castiglione, condensed succession

Stop 1.3:
The marginal palaeoescarpment, megabreccia, and the epi-breccia deposits

Walking on the top surface of the Calcare Massiccio towards the east for a few tens of meters, the plateau-top condensed succession suddenly disappears, and is laterally replaced by a chaotic body, made of limestone blocks up to several meters across. These blocks form an eterometric clast-supported megabreccia, resting unconformably on the Calcare Massiccio and the Rosso Ammonitico-equivalent, through an erosional surface that truncates the normal succession laterally at high angle and dips towards the east. The breccia is in turn seen to be onlapped by east-dipping basinal strata of the Maiolica Fm., so the area must represent the local marginal palaeoescarpment of the Sabina Plateau. The blocks are often stacks of beds of Bugarone inferiore, while the number of clasts of Calcare Massiccio increases downwards, as a result of sourcing from a relatively thicker section of this unit. The clasts of Massiccio are interesting because they are often made of a spectacular subaerial exposure facies, with dissolution cavities infilled with brown sediment, clotted fabrics, etc. The Characean-rich continental deposits described by Farinacci (1967) probably were sampled in these clasts. As mentioned above, this confirms that the upper levels of the unit were subjected to non-marine deposition, and vadose diagenesis, prior to drowning.

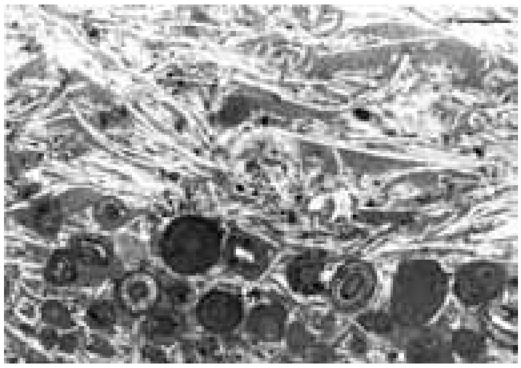

Figure 9 - Bajocian posidoniid-rich deposits, interpreted as overbank deposits, with oolites, peloids, and benthic forams. Scale bar=0.5 mm (upper right). Castiglione, condensed succession.

One striking aspect of the breccia resides in its matrix. It is, in fact, clearly seen that the inter-clast spaces

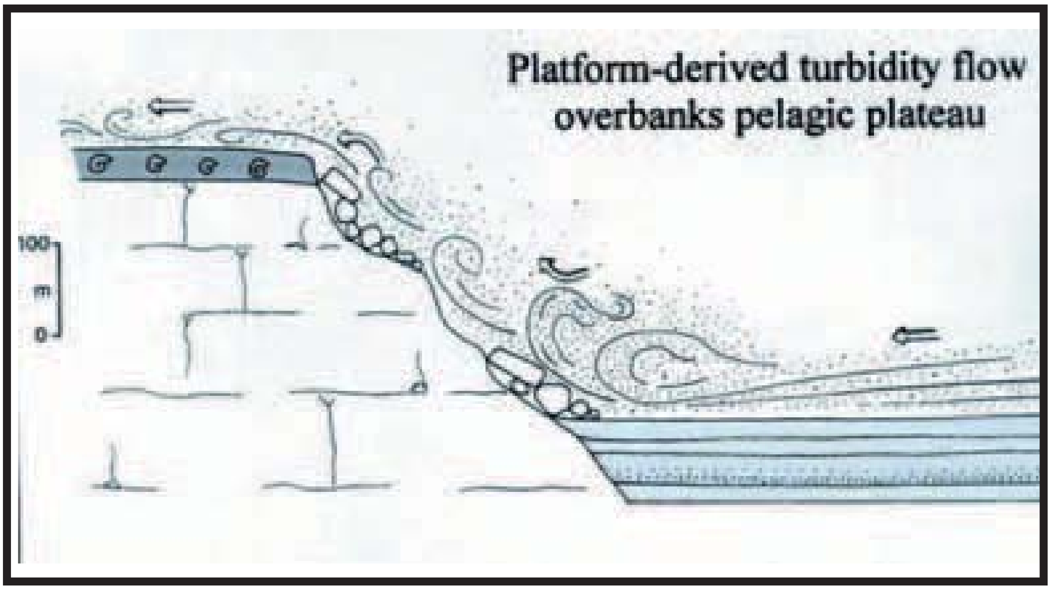

Figure 10 - Cartoon depicting the inferred overbank process, triggered by the breaking of a turbidity flow against the marginal escarpment, causing the plateau top to be swept over by mixed oolite-posidoniid sediments. Grey: pelagic deposits (with turbidites in the basin).

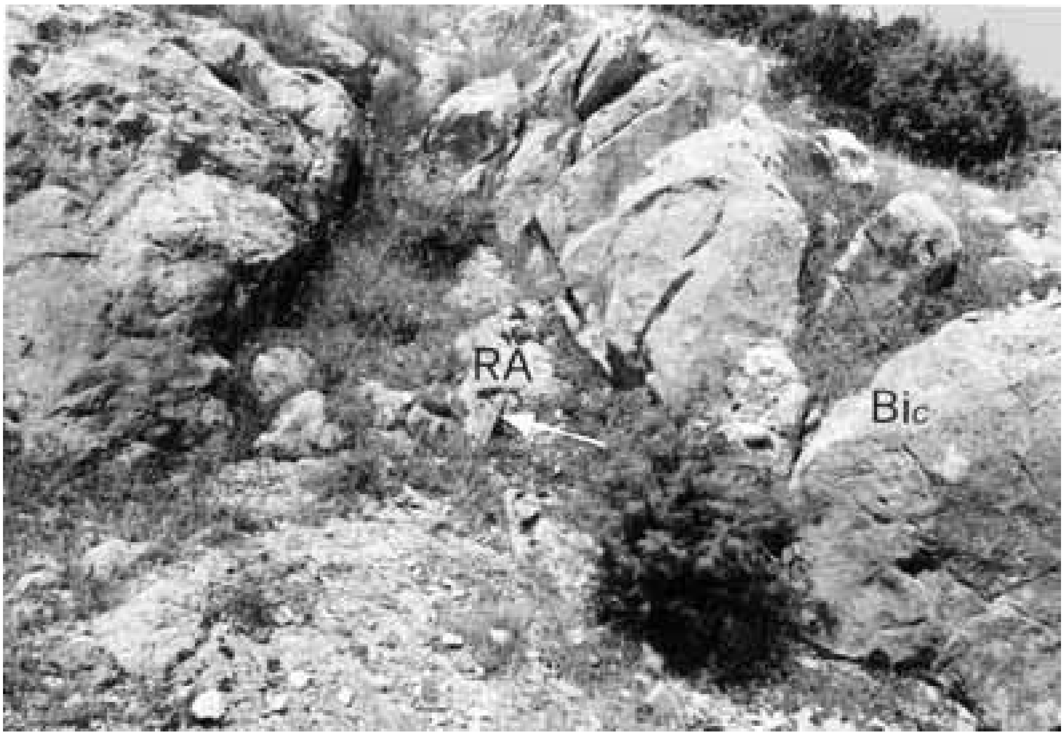

Figure 11 - Megaclasts of Bugarone inferiore (Bic) and "matrix" of plastic Rosso Ammonitico (RA) (arrow indicates hammer). Castiglione.

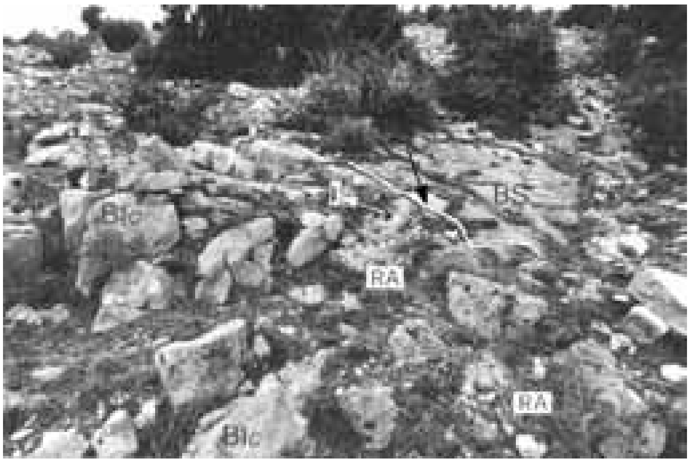

Figure 13 - Megabreccia, with large rotated beds of Bugarone inferiore (Bic), with an intervening plastic "matrix" of nodular Rosso Ammonitico (RA), draped by a thin veneer of Bugarone superiore (BS) (underlined contact, arrow).

were filled with Rosso Ammonitico-equivalent while it was still plastic: the (light brown) nodular marls often act as cushions between larger blocks, or form load-induced "flames" (Fig. 11).

This is unusual for two main reasons: 1. the matrix is in fact older than the clasts - it constitutes some sort of a "recycled material" matrix; 2. the Rosso Ammonitico-equivalent had a slower diagenesis than the Bugarone inferiore, which produced instead angular clasts that were in no way folded. This peculiar behaviour of the Rosso Ammonitico-equivalent is well seen across the whole Castiglione area, because neptunian dykes crossing it often have irregular and ill-defined walls, and form a network of irregular anastomosed veinlets.

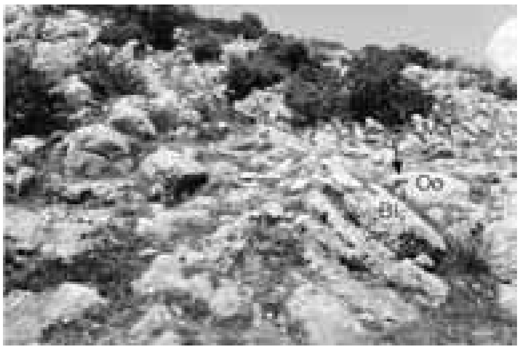

Figure 12 - The Megabreccia at Castiglione; a fallen and rotated stack of beds of Bugarone inferiore (Bic) is overlain by ponded pockets of oolite-rich overbank deposits (Oo) (see text). Both are onlapped by the Maiolica (Ma) in the background. The stack apparently slid for only a few tens of meters, and then came to a halt – as the whole megabreccia at Castiglione – onto a concave spoon-shaped erosional surface of the plateau escarpment. See hammer (arrow) for scale.

The contact of the megabreccia with the Calcare Massiccio became the site of fracturing in the Early Cretaceous, as demonstrated by a dyke, probably several meters wide but partially covered by vegetation, made of Maiolica.

The megabreccia is seen to rest on the escarpment, down to a point of elevation that is about 100 m lower than the local top of the Calcare Massiccio. Here, at the base of the outcrop, the erosional surface of the Calcare Massiccio forms a horizontal plane, thus defining an overall listric geometry that also serves to explain why the tail of the megabreccia remained perched on the escarpment – which is what we see here today – while other blocks must have fallen into the basin.

Epi-breccia deposits occur in two main forms: the rarest is represented by perched ponds of oolite-posidoniid sediment, up to 20 cm thick. Their origin, according to the interpretation offered above, should be the result of overbanking of platform-derived turbidity flows (Fig. 12).

By far the most widespread epi-breccia deposit, is a discontinuous veneer of Bugarone superiore, which levels the irregular top of the breccia, and represents an example of the composite pelagic facies association (see above), resting on both the clasts and the nodular matrix (Fig. 13).

Careful inspection of every outcrop, has demonstrated that no sediments older than the Kimmeridgian (*C. divisum* Zone) are present. The Lower Tithonian often occurs with an ammonite assemblage which is dominated by large specimens of *Hybonoticeras hybonotum*, also with fish teeth. These sediments are in turn unconformably overlain by the onlapping chert-bearing Maiolica, and can be locally silicified as a result (see Santantonio *et alii*, 1996 for a discussion).

Regarding the age of the megabreccia, the most reliable constraint is the occurrence of the oolite-rich ponds. Because this occurrence is so exceptional, an age correlation of the ponds with the Lower Bajocian

Figure 15 - Uppermost escarpment, plateau-margin morphology: sloping erosional surface, truncating several beds of Bugarone inferiore (hammer). The Maiolica (Ma) in the background onlaps this surface, which is silicified. The Maiolica in the foreground fills the detachment scar described in previous figure, and is in vertical stratigraphic contact with the Bugarone inferiore. Castiglione area.

oolite-bearing beds in the upper part of the plateau-top Bugarone inferiore is more than a tempting option. There are at least two lines of evidence suggesting this was probably indeed the case:

1. The facies of the uppermost few meters of the plateau-top Bugarone inferiore is more ammonite-rich than the lower levels. This suggests that a plateau-edge most-condensed facies replaced a plateau-interior, less-condensed facies, as the result of backstepping of the plateau margin due to the rockfall. This means a rejuvenation of the "panettone" architecture.

2. Oolites are also found in posidoniid-rich neptunian dykes crossing the Rosso Ammonitico-equivalent. It is conceivable that these fissures, as well as the megabreccia, were formed as the product of some earthquake shock, perhaps related to a minor phase of basin-wide extension. Therefore, we can hold as the collective product of the same event: a) the initiation of the turbidity current from the slopes of the Latium-Abruzzi Platform, b) the backstepping of the plateau margin and origin of the breccia, and c) the eventual breaking of the turbidity current against the escarpment and the overbanking, with the platform-derived sediment climbing the breccia, partly filling the fissures, and scouring the plateau top.

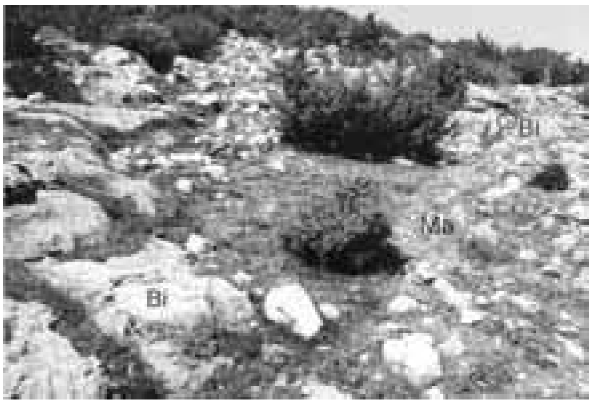

Figure 14 - The Maiolica (Ma) fills a semicircular detachment scar carved in the Bugarone inferiore (Bi) (vegetation). See hammer (circled) for scale. Castiglione.

Stop 1.4:

Multiple detachment scars carved in the condensed succession, and the erosional palaeomorphology of the plateau margin

Climbing up the megabreccia, we finally reach one of the areas from which the fallen blocks must have been sourced. This is where the basinal beds of the Maiolica directly onlap the condensed plateau-top succession. The contact is strongly irregular, and one prominent erosional surface defines a scar into the Bugarone inferiore that is subcircular in plane view (Fig. 14). This is several meters across, has steep subvertical walls, and is filled by Maiolica, covering an earlier discontinuous drape of Bugarone superiore. Another smaller accessory scar forms a further indentation into the Bugarone inferiore, and is completely filled with Bugarone superiore, with Tithonian ammonites of the *H. hybonotum* Zone. These scars are sculpted into a gently sloping erosional surface, truncating beds of the Bugarone inferiore, and this surface represents a vestige of the uppermost palaeoescarpment and is onlapped by a Maiolica that is latest Berriasian/ Valanginian in age (M.C. Giovagnoli and F. Cecca, pers. comm.) (Fig. 15). Both this palaeosurface and the draping Bugarone superiore are silicified at the contact sites with the Maiolica. The age of this onlapping Maiolica is younger than the base of the Maiolica in the plateau-top succession, which is also topographically higher, so a Maiolica-on-Maiolica unconformity must have occurred as the final stage of burial of the escarpment, marking the end of the basin-fill history that started in the Sinemurian.

A final general remark on the Castiglione area regards the thickness of the post-Maiolica units. Having seen how the Maiolica onlapped the uppermost escarpment, so that the history of the Sabina Plateau came to an end, one might have expected younger formations to have an even thickness across both the former plateau and the basin. The Aptian to Lower Cenomanian Marne a Fucoidi Fm., and the Cenomanian to Eocene Scaglia Bianca and Scaglia Rossa Formations, are instead unexpectedly thin on the plateau. This strongly suggests that differential compaction played a significant role, in that the area formerly occupied by the Jurassic Sabina Plateau continued to act as a subdued intrabasinal high, flanked by secondary (compaction-induced) slopes for tens of million years after its burial. These slopes were developed

Figure 16 - Silicified cryptalgal laminites. Olistolith of Calcare Massiccio at Mt. Cimitella.

Figure 17 - Top of a huge olistilith (>100 m longer axis) (OL1,) overlain by thin Bugarone superiore (Kimmeridgian), and by Aptychus and Saccocoma limestone, in turn bearing breccias with large clasts of Calcare Massiccio (OL2)

above the former plateau/basin transition, and became the sites of sediment sliding and section thinning. Perhaps this was also enhanced by a modest phase of tectonic rejuvenation in the Early Cretaceous, that is documented across the whole area by neptunian dykes filled with Maiolica.

DAY 2

Stop 2.1:

The hill-size olistolith at Le Cimitelle

Take the road which climbs from Stroncone to Piani di Stroncone; before reaching Piani di Stroncone, turn left for Le Cimitelle.

The area of Mt. Cimitella, on which the small village of Le Cimitelle is built, is located near the northern termination of the Sabini Mts.. Here a huge block of Calcare Massiccio, more than 100 m across, is seen embedded in the basinal Calcari Diasprigni Fm.,

Figure 18 - A tract of the main N-S palaeoescarpment at Mt. Macchialunga. Basin-margin beds of Maiolica abut the Calcare Massiccio of the Sabina Plateau (darker vegetation).

representing the westernmost termination of the Sabina Basin succession close to the palaeoescarpment. This block is part of a prominent north-south trending alignment of megabreccias and isolated olistoliths. Several sedimentary and diagenetic features are most notable in the area.

The Calcare Massiccio is severely silicified, the proportion of visible chert being a direct function of proximity to the contact with the radiolarian cherts. Typical sedimentary structures of the peritidal environment are underlined by chert, as cryptalgal lamination (Fig. 16).

A very condensed succession of Corniola-equivalent, Rosso Ammonitico-equivalent, and Bugarone inferiore, is found resting unconformably on the block. This must represent a former epi-escarpment composite facies association, that remained attached to the fallen block of Calcare Massiccio as the escarpment retreated.

Mapping around Le Cimitelle reveals that the base of the olistolith actually rests on beds belonging to the upper part of the Calcari e Marne a *Posidonia*, so it is not unlikely that the detachment of this block was synchronous with the emplacement of the megabreccia at Castiglione in the Bajocian. By the way, this constitutes further stratigraphic evidence that the unconformable condensed deposits, being all consistently older than the encasing basinal formation, were indeed former epi-escarpment deposits, and not a drape postdating the emplacement of the block. Also, the actual palaeoescarpment tract that sourced the block, is exposed a mere 200 m to the west, indicating that the block underwent only minimal transport.

STOPS 2.2 – 2.3

The basin-margin deposits and palaeoescarpment tract at Mt. Macchialunga

Along the eastern slopes of Mt. Macchialunga area, another tract of the Sabina Palaeofault escarpment is beautifully exposed, along with the breccia-bearing termination of the Sabina basinal wedge.

Stop 2.2:

Olistoliths and bedded breccias in the Calcari ad aptici e *Saccocoma*

Take the road from Stroncone all the way to Piani di Stroncone. Take Valle Leona to the SSW. Walk towards the eastern slopes of Mt. Macchialunga.

The Upper Jurassic deposits found ~1 km ESE of the Mt. Macchialunga summit have quite interesting sedimentological features. An olistolith of Calcare Massiccio bears on its top a mound-shaped bed package of nodular Bugarone superiore (max 5.5 m, but much less near the edges), having at its base an Upper Kimmeridgian ammonite assemblage with *Taramelliceras (T.) compsum* (Oppel). This is followed by laminated *Saccocoma* sands with intercalations of Bugarone superiore. Upsection, these sands also bear graded and laminated breccias up to few decimeters thick, and they become cherty. Then another olistolith occurs, about 3 m thick, capped in turn by about 2 m of Bugarone superiore, and then draped by cherty *Saccocoma*-rich deposits, that in 5-6 m change vertically to the Maiolica (Fig. 17). While it must be stressed that these thickness figures have strong lateral variability, a general interpretation can be offered, envisaging the repeated ephemeral development of epi-olistolith condensed sedimentation that could only last until the sea-bottom topography was levelled with bioclastic and lithoclastic deposits.

Stop 2.3:

The upper palaeoescarpment tract

Along an easy 1 km walk from the previous stop towards the west, the beds of the basin-margin succession can be traced laterally westwards until they abut the Calcare Massiccio, that constitutes the backbone and summit of Mt. Macchialunga (Fig. 18). The contact strikes approximately N-S. Topographically lower, small ponds of epi-escarpment deposits occur between the Calcare Massiccio and the Maiolica and these have yielded a large specimen of the Tithonian species, *Aspidoceras rafaeli* (Oppel).

DAY 3

Stop 3.1:

Resedimented deposits of the Sabina Basin (Reatini Mts.)

Introduction to the geology of the Reatini Mts.

The Jurassic deposits of the Reatini Mts. were originally sedimented in the Sabina Basin *s.s.* (Fig. 1), as defined in the general introductory chapter. As such, they are typically represented by thick, resediment-dominated successions (Chiocchini *et alii*, 1975). In general, the volumes of material derived from the Latium-Abruzzi Platform decrease westwards, *i.e.* in the areas visited during days 1 and 2 of the present field-trip. Sections more proximal to the L-A Platform received so much allochtonous sediment, that placing formation boundaries is often a difficult exercise. It must be noted that recent research demonstrates that the Sabina Basin possessed internal structural complications in the Jurassic, in the form of pelagic carbonate platforms and ramps, which generally became buried with basinal deposits in the Middle Jurassic (see above) (Leonardi *et alii*, 1997). This indicates these were relatively deeper-water highs with respect to the Sabina Plateau, with the exception of a few small areas, where condensed deposits are as young as the Kimmeridgian – Tithonian (e. g. Mt. Rosato near Poggio Bustone).

More research is currently underway, including a geological sheet mapping project, which will hopefully result in a better understanding of the palaeofault and facies architecture of the Reatini Mts., and of the processes that influenced the shedding of shallow-water carbonate into the basin during the Jurassic.

The structural setting of the Reatini Mts. is, like the Sabini Mts., dominated by east-verging thrusts, which bound discrete tectonic units mostly made of Mesozoic and Lower Tertiary carbonate formations (Cosentino *et alii*, 1991). One peculiar stratigraphic aspect of the area is the local outcrop of Upper Triassic peritidal dolostones at the hangingwall of thrust faults.

The Colle Casarine section

This section crops out along the dirt road connecting Gli Osti to Fontanile Versanello, between Colle Varco and Colle Casarine (Cantalice Alto, RI). It is a typical mixed pelagic-resedimented section with several

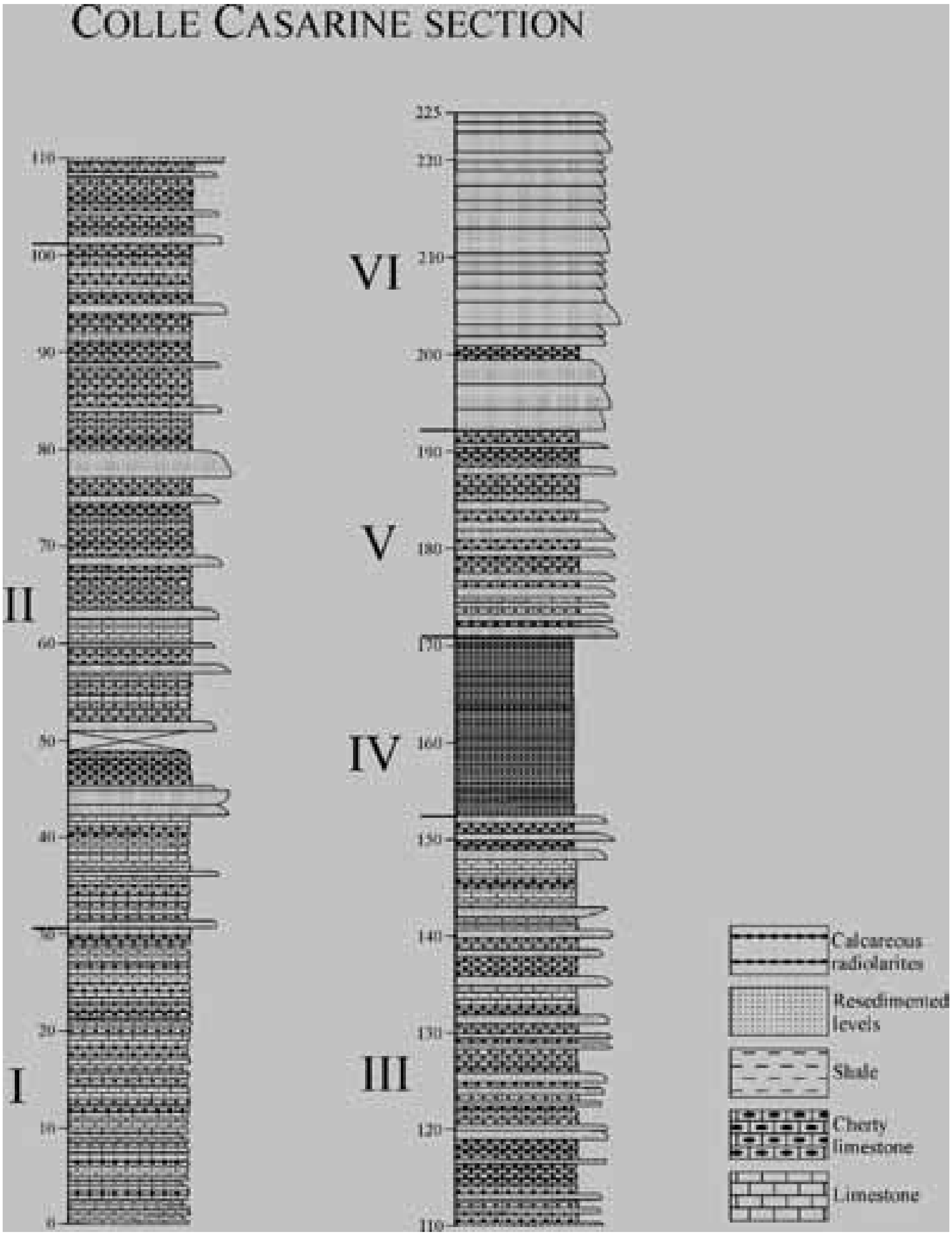

Figure 19 - The Colle Casarine section.

sediment gravity flows. These include: turbidites, composed of carbonate platform-derived grains (ooids, peloids, oncoids, benthic forams, algae, and skeletal debris), and lithified clasts, with incomplete Bouma sequences (generally T_{a-b}, but rarely T_{a-c}, T_a, T_b, or T_c); it also includes debris flows with soft, rounded and flat micritic clasts, and flat calcarenitic clasts. Examples of deposits with border-line features, between different kinds of sediment transport, often occur, including beds with very thick non-organized conglomeratic bases, followed by much thinner, graded and laminated intervals.

In this stop, only the Calcari e Marne a Posidonia Fm. and the Calcari Diasprigni Fm. will be examined (Upper Toarcian *p.p.* - Kimmeridgian *p.p.*). The top of the latter unit is not well exposed, due to minor faulting and soil cover. The transition between the Calcari e Marne del Serrone, and Calcari e Marne a Posidonia Fms., is continuous and very gradual. The base of the latter is marked by an increase in carbonate content, and by the appearance of chert. The thickness of the measured section (Fig. 19) totals about 225 m. Six intervals, with different resediments/pelagites ratio, have been recognized. In general, the frequency and thickness of resedimented deposits increase up-section, along with changes in their composition.

The interval I, from 0 m to 30.6 m, comprises grey to pale brown micritic (mudstone to wackestone) limestone and marly limestone. Grey chert occurs in nodules and rarely in ribbons. Centimetric greenish marly intercalations are also present. The limestone contains radiolarians and posidoniids. Rare ammonites occur only in the lower beds. Bed thickness ranges between 10 and 30 cm.

The interval II, from 30.6 m to 101.2 m (70.6 m), is characterized by the appearance of gravity flow deposits. Grey to pale brown limestones, cherty limestones and radiolarian sands are interbedded with sporadic detrital beds (resediments/pelagites ratio 1:4). In the pelagic levels, grey chert occurs as nodules and, more frequently, as ribbons, and becomes reddish upsection. White chert is typical of resedimented beds. Resedimented levels consist of white packstone, rarely grainstone, to wackestone, normally graded (incomplete Bouma sequence T_{a-b}). Turbidites with conglomeratic bases and debris flow deposits occur at several levels. The clasts in these deposits are generally flat and several centimeters across, and are made of a pink micrite and/or of calcarenite, with a very coarse-to-medium sand matrix. Bed thickness ranges between 10 and 40 cm (limestones), and 10 and 20 cm (chert ribbons). Resedimented levels are 10 to 255 cm thick. Pelagic deposits only bear posidoniids and radiolarians.

The interval III, from 101.2 to 152.6 m (51.4 m), records an increase in resediments/pelagites ratio (1/3). The pelagic beds comprise radiolarian sands with posidoniids, and subordinate ribbon cherts, red and pink in colour. Parallel lamination occurs in almost all these beds, mostly a product of changes in the average size of biogenous components. The last occurrence of posidoniids is recorded at 150 m.

The resedimented levels are normally graded (incomplete Bouma sequence T_{a-b}), medium to very fine sand-size. Isolated T_a (fine or very fine sand) divisions occur in beds 10-20 cm thick. All detrital beds contain oolites and other platform-derived grains (ooids, peloids, oncoids, benthic forams, and skeletal debris). Bed thickness ranges between 3-10/40 cm (pelagic limestone), 5-30 cm (chert), and 10-80 cm (detritic levels).

With the exception of one gravel-size level (131.8 m to 132 m), this interval is characterized by the absence of coarse resediments.

The interval IV, from 152.6 m to 171 m (18.4 m), is characterized, again (like the first interval), by the complete absence of platform-derived gravity flow deposits. It comprises white-greenish thin bedded (1-10 cm) radiolarian sands with subordinate white-greenish radiolarian-rich micrites, interbedded with red ribbon cherts. Parallel lamination occurs in almost all beds.

The interval V, from 171 m to 192.7 m (21.7 m), marks the reappearance of gravity flow deposits, with a resediments/pelagites ratio of 1/1. Amorphous cherts, radiolarian sands and subordinate radiolarian-rich micrites are interbedded with normally graded turbidites, very coarse to very fine sand-size (incomplete Bouma sequences T_{a-b}, $T_{a, c}$). Isolated T_a and T_c beds are also common. Only one detritic level (from 188.6 m to 189.35 m) displays a complete Bouma T_{a-e} sequence, from very coarse to fine-very fine sand-size. Resedimented beds contain oolites up to 189,35 m, and become more bioclastic up-section. In the upper portion of this interval (up to 185 m), green and red chert, with pinch-and-swell structures, occurs in the pelagic beds. Bed thickness ranges from between 2-10 cm (pelagites), and 10-90 cm (resediments).

The interval VI, from 201.2 m to 225 m, is almost solely constituted of resedimented deposits, with the exception of a few centimeters (between 199.5 m and 201.2 m) of grey/green thin parallel- and cross-laminated calcareous radiolarites with sponge spicules, probably the product of current winnowing. The turbidites are normally graded, generally from medium/fine to very fine sands. This is the first interval with common Bouma T_{a-c} sequences. Isolated T_c beds also occur. Only three detrital beds are coarse-grained, with centimetric flat micritic clasts at the base, scattered in a medium-coarse sand matrix. These levels are poorly sorted and normally graded. White chert occurs as nodules, lenses and ribbons. All detrital beds show a variable degree of silicification and desilicification. Bed thickness ranges between 15 cm and 3 m.

As noted above, the striking feature of this section resides in the occurrence of abundant platform-derived material. Additional evidence in this respect is found in another section, at Fosso Versanello (~2 Km NE of Colle Casarine), where a continuous succession, ranging up to the Maiolica Fm., is strongly resedimented throughout the Cretaceous.

These mixed pelagic/resedimented successions record the ongoing productivity of the Latium-Abruzzi carbonate platform during the whole Jurassic. However, a comparison with other coeval successions in the western, more distal, part of the Sabina Basin, clearly shows that the Late Bajocian to Oxfordian was a time of severe contraction of sediment export from the platform. This is evidenced by the virtually complete absence of resedimented beds in the Calcari Diasprigni Fm. (radiolarian cherts). Several authors have noted that basinal pelagic successions in the Umbria-Marche and Sabina regions document discrete steps in the palaeoceanographic, palaeobiological, and carbonate productivity history of the Western Tethys, which are also recorded as shifts in the $\delta^{13}C$ curve. The palaeoceanographic significance of the enigmatic posidoniid-bivalve deposits, and of the strikingly oligotypic fauna that characterize such an abnormally long time span (~10 My) over vast submarine areas of our planet, is relatively poorly understood. The fossil content of the radiolarian cherts is even more discouraging, since radiolarians apparently became the almost exclusive inhabitants of the water column over a period of ~20 My. Although it is clear that what we see today is also the product of selective preservation, it has been argued that the long-lasting dominance of radiolarians, and the fact that they form deposits that are often entirely carbonate-free, corresponds to a period of crisis in carbonate productivity in the marine environment that occurred on almost, a global scale. This is supported by the commonly accepted notion that, at the time, carbonate mud in pelagic successions was essentially derived from peritidal platforms in the form of peri-platform ooze: calcareous nannoplankton accounts for only a very minor proportion of the carbonate rock constituents in pre-Tithonian pelagic successions. If we can accept this, then pelagic successions would be seen to be genetically linked to the platform successions, so that a Jurassic pelagic succession that is starved of carbonate, must record lowered production rates on adjacent platforms. This process could be due to: a) a carbonate productivity crisis, and/or a turnover of carbonate producers, that affected both the shallow-water and, (to a relatively minor extent), the pelagic carbonate factories; b) a halt in the platform subsidence; c) a phase of drowning or of subaerial exposure of the platform.

In our case, the sedimentary record from the Latium-Abruzzi Platform / Sabina Basin system suggests that the time of deposition of Middle-Upper Jurassic radiolarian cherts saw changes that impacted several variables within the carbonate system, but was neither a time of platform drowning, nor of subaerial exposure. These changes must have affected: 1, the type of organic and inorganic products (e.g. reduction of mud); 2, production rates on the platform, and export rates (both reduced); and , maximum distance covered by sediment gravity flows (limited to a relatively narrow belt outside the platform).

For a more thorough discussion on this subject, see papers by Baumgartner (1987), Cecca *et alii* (1990), Bombardiere (1993), Santantonio (1993), Colacicchi & Bigozzi (1995), Bartolini *et alii* (1996), Santantonio *et alii* (1996), Bartolini & Cecca (1999), Picotti & Cobianchi (2000), Morettini *et alii* (2002).

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Back Cover:
field trip itinerary

FIELD TRIP MAP

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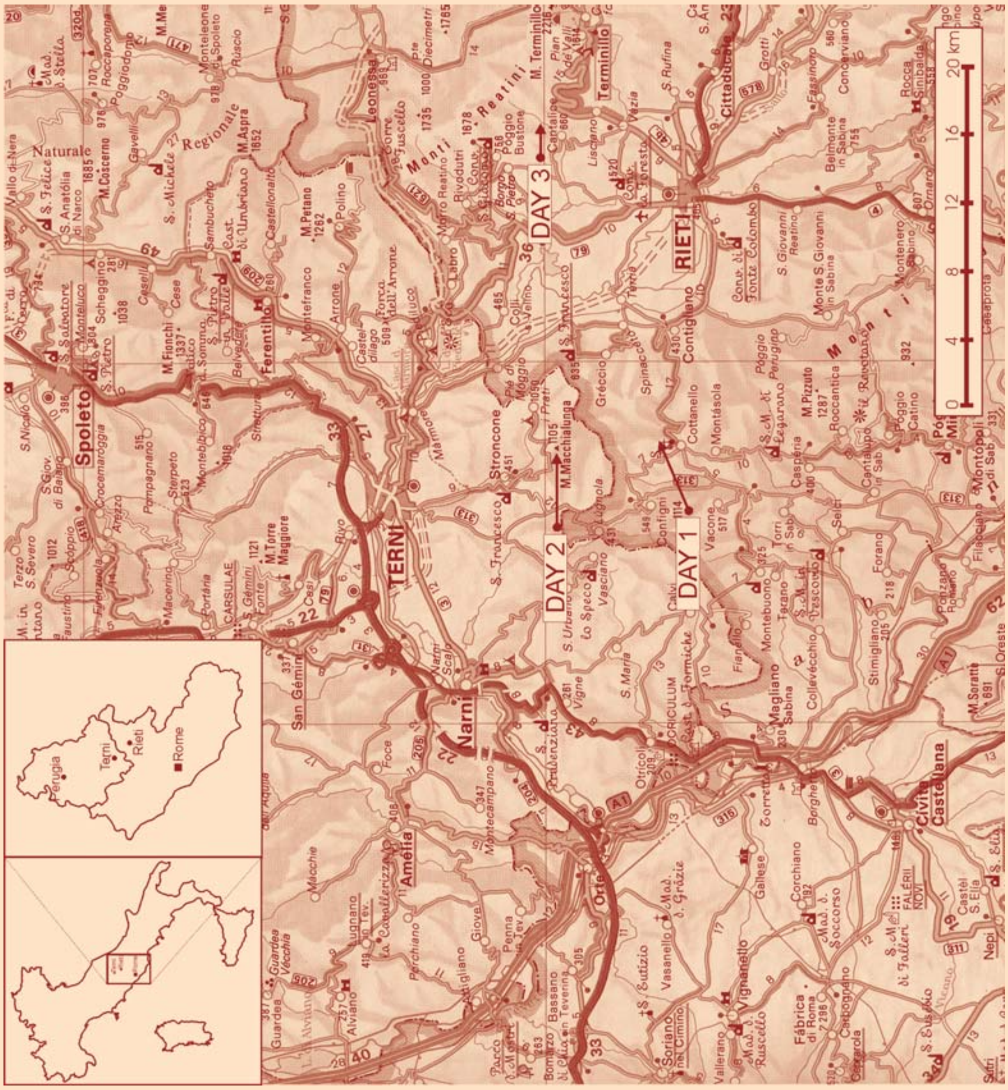

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