Tenth International Congress on Rudist Bivalves

RUDISTS 2014

Bellaterra, June 22-27

Post-Congress Field Trip
Upper Cretaceous rudists from the Noguera and the Pallars-Jussà

Field Trip leaders: J.M. Pons and E. Vicens

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POST-CONGRESS FIELD TRIP

Field trip: Upper Cretaceous rudists from the Noguera and the Pallars-Jussà

Field trip leaders: ***Jose Maria Pons and Enric Vicens***

	Wednesday 25 of June
17.00	Fieldtrip starts from **Hotel Campus** Ride Bellaterra – Serra d'Arquells Bellaterra – (AP-7) – Martorell – (A-2) – Igualada – Cervera – (C-352) – Agramunt – (C-74) – Artesa de Segre – (C-26) – Cubells – Serra d'Arquells
18.30	**STOP 1: Serra d'Arquells** Upper Campanian with: *Hippurites radiosus* des Moulins, *Hippuritella lapeirousei* (Goldfuss), *Biradiolites lameracensis* Toucas, *Lapeirousia* sp., *Praeradiolites boucheroni* Toucas.
19.00	Ride Serra d'Arquells – Presa de Camarasa Serra d'Arquells – Cubells – Camarasa – (C-13) – Presa de Camarasa
19.30	**STOP 2: Road C-13** STOP 2a: Km 48, Rendisclera de La Maçana Lower Campanian (lower horizon) with: *Hippurites vidali* Matheron, *Hippuritella variabilis* (Douvillé), *Hippuritella* sp., *Vaccinites archiaci* (Munier-Chalmas), *Biradiolites leychertensis* Toucas, *B. siracensis* Toucas, *Praeradiolites subtoucasi* Toucas. STOP 2b: Km 55, Clot de Vall-llobar Upper Campanian with: *Hippurites radiosus* des Moulins, *Hippuritella lapeirousei* (Goldfuss), *Biradiolites chaperi* Toucas, *Praeradiolites boucheroni* Toucas, *Radiolitella pulchellus* (Vidal).
20.30	Ride Clot de Vall-llobar – Cellers Clot de Vall-llobar – (C-13) – La Baronia de Sant Oïsme – Pas de Terradets – Cellers Arrival at **Hotel Terradets** around 21.00h
	Thursday 26 of June
09.00	Fieldtrip starts from **Hotel Terradets** Solar protection for skin and eyes, a hat or a cap, and suitable footwear is highly recommended. Ride Cellers – Montsec de Pedroneta Cellers – (C-13, C-12) – Àger – (mountain road) – Montsec de Pedroneta
10.00	**STOP 3: Montsec de Pedroneta** STOP 3a: Upper Turonian with: *Hippurites resectus* Defrance, *Vaccinites petrocoriensis* Douvillé, *V. rousseli* Douvillé, *Praeradiolites pailletei* (d'Orbigny). Coniacian with: *Hippurites socialis* Douvillé, *Hippuritella* sp. gr. *toucasi* d'Orbigny, *Vaccinites moulinsi* d'Hombres-Firmas, *Radiolites angeiodes* Lamarck, *R. radiosus* d'Orbigny, *R. vallispetrosae* Astre, *Biradiolites canaliculatus* d'Orbigny, *Praeradiolites requieni* d'Hombres-Firmas. STOP 3b: Lower Santonian with: *Hippurites matheroni* Douvillé, *H. praecessor* Douvillé, *Vaccinites beaussetensis* Toucas, *Radiolites laciniatus* Vidal, *R. radiosus* d'Orbigny, *R. sauvagesi* (d'Hombres-Firmas), *R. squamosus* d'Orbigny, *B. angulosissimus* Toucas, *B. canaliculatus* d'Orbigny, *Fossulites undaesaltus* Astre.

	STOP 3c: Upper Santonian with: Hippurites canaliculatus Rolland du Roquan, H. microstylus Douvillé, H. cf. socialis Douvillé, H. turgidus Rolland du Roquan, Hippuritella maestrei (Vidal), H. sulcatissima Douvillé, Vaccinites galloprovincialis Matheron, Radiolites angeiodes Lamarck, Biradiolites acuticostatus (d'Orbigny), B. angulosissimus Toucas, B. carezi Toucas, B. ibericus (Vidal), Praeradiolites caderensis Toucas, P. plicatus Lajard, Negrel & Toulouzan, P. toucasi (d'Orbigny), Sphaerulites boreaui Toucas, Apricardia sp., Monopleura montsecana Vidal, M. minuta Pons, non Vidal, Plagioptychus toucasi (d'Orbigny), Plagioptychus sp.
13.00	Ride to Coll d'Ares, at the top of the Montsec Panoramic view Lunch break
14.30	**STOP 4: Coll d'Ares** Lower Campanian with: *Hippurites vidali* Matheron, *Hippuritella variabilis* (Douvillé), *Vaccinites archiaci* (Munier-Chalmas), *Biradiolites leychertensis* Toucas, *B. siracensis* Toucas, *Lapeirousia* sp., *Praeradiolites subtoucasi* Toucas.
15.00	Ride Coll d'Ares – Moror Coll d'Ares – **(x)** – Sant Esteve de la Sarga – Beniure – Alzina – Moror **(x)** Crossing of the Montsec de Sant Esteve along the Campanian
16.00	**STOP 5: Moror** Upper Campanian with: *Hippurites radiosus* des Moulins, *Hippuritella lapeirousei* (Goldfuss). Lower Maastrichtian with: *Hippuritella castroi* (Vidal), *Biradiolites ara* Pons, *Biradiolites chaperi* Toucas, New genus *moroi* (Vidal), *Praeradiolites boucheroni* Toucas, *Monopleura moroi* (Vidal), *Monopleura* sp.
19.00	Ride back Moror – (LV-9124) – Cellers Arrival at **Hotel Terradets** around 19.30h
	Friday 27 of June
09.00	Fieldtrip starts from **Hotel Terradets** Don't forget to take your baggage with you; we won't come back to the hotel. Solar protection for skin and eyes, a hat or a cap, and suitable footwear is highly recommended. Ride Cellers – Collada Pelosa Cellers – (C-13) – Tremp – (C-74) – Isona – (C-363, mountain road) – Abella de la Conca – (mountain road) – Cal Borrell – Collada Pelosa
10.00	**STOP 6: Les Collades de Basturs** Sorry, this is not really a stop. We will wander on rudists up and down along four km. Don't forget to take with you your lunch pack and drinks; lunch break will be on the outcrop, far from the vehicles. Lower Santonian with: *Hippurites matheroni* Douvillé, *H. microstylus* Douvillé, *H. praecessor* Douvillé, *H. socialis* Douvillé, *H. sublaevis* Matheron, *Hippuritella maestrei* (Vidal), *H. toucasi* d'Orbigny, *Vaccinites beaussetensis* Toucas, *V. galloprovincialis* (Matheron), *V. giganteus major* Toucas, *V. zurcheri* Toucas, *Radiolites angeiodes* Lamarck, *R. squamosus* d'Orbigny, *R. vallispetrosae* Astre, *Biradiolites acuticostatus* (d'Orbigny), *B. angulosissimus* Toucas, *B. beaussetensis* Toucas, *B. canaliculatus* d'Orbigny, *B. carezi* Toucas, *Bournonia excavata* (d'Orbigny), *Praeradiolites caderensis* Toucas, *P. plicatus* Lajard, Negrel & Toulouzan, *P. toucasi* (d'Orbigny), *Apricardia* sp., *Bayleia* sp., Monopleuridae indet., *Plagioptychus aguilloni* (d'Orbigny), *P. toucasi* Matheron.

17.00	Ride back to Bellaterra Basturs – Sant Romà d'Abella – (LV-5113) – Isona – Coll de Comiols – Artesa de Segre – (C-74) – Agramunt – (C-352) – Cervera – (A-2) – Igualada – El Papiol – (AP-7) – Bellaterra Possibility of an extra stop close to Isona, Lower Maastrichtian with: *Hippurites castroi* Vidal, *Radiolitella pulchellus* (Vidal). Panoramic view of the Tremp Basin from Coll de Comiols
20.00	End of the fieldtrip at **Hotel Campus**

INTRODUCTION

The Upper Cretaceous crops out at the three units of the piggy back thrusting sequence developed in South-central Pyrenees; namely, from South to North: **Serres Marginals**, **Montsec**, and **Bóixols**. The northern unit started moving southwards in the Late Cretaceous and the southernmost unit stopped moving in the Late Oligocene. Total shortening is estimated in 165 km.

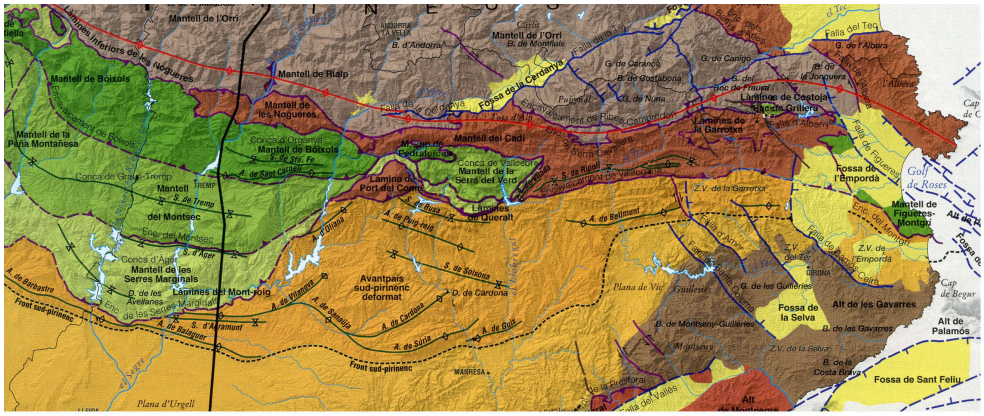
Restitution of the Upper Cretaceous sediments to their original location, depicts, north of the emerged **Ebro Massif**, a basin deepening from South to North, where it communicated westwards with the former Gulf of Biscay. During Late Cretaceous, this basin subsided and expanded covering part of the **Ebro Massif**, due to the tectonic context but also to the progressive global sea level rise.

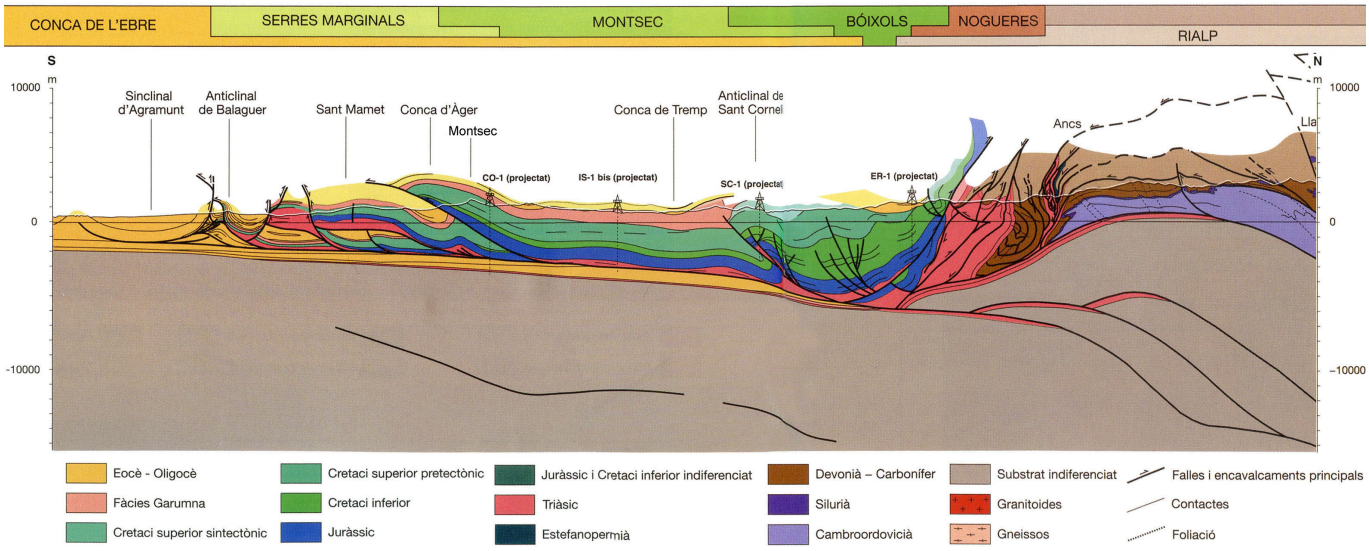
Nine third-order depositional sequences are currently distinguished within the Upper Cretaceous in south-central Pyrenees: Santa Fe 1 (Cenomanian), Santa Fe 2 (early to middle Turonian), Congost 3 (late Turonian to early Coniacian), Sant Corneli 4 (Coniacian to early Santonian), Vallcarga 5 (late Santonian), Vallcarga 6 (early Campanian), Vallcarga 7 (middle Campanian), Areny 8 (late Campanian), and Areny 9 (Maastrichtian); although details, age, and boundaries are still under discussion. Shallow carbonate platforms or mixed siliciclastic-carbonate platforms, both with the conspicuous presence of rudist bivalves, developed at most of the depositional sequences; that is, rudists occur at different time intervals in different locations in the basin.

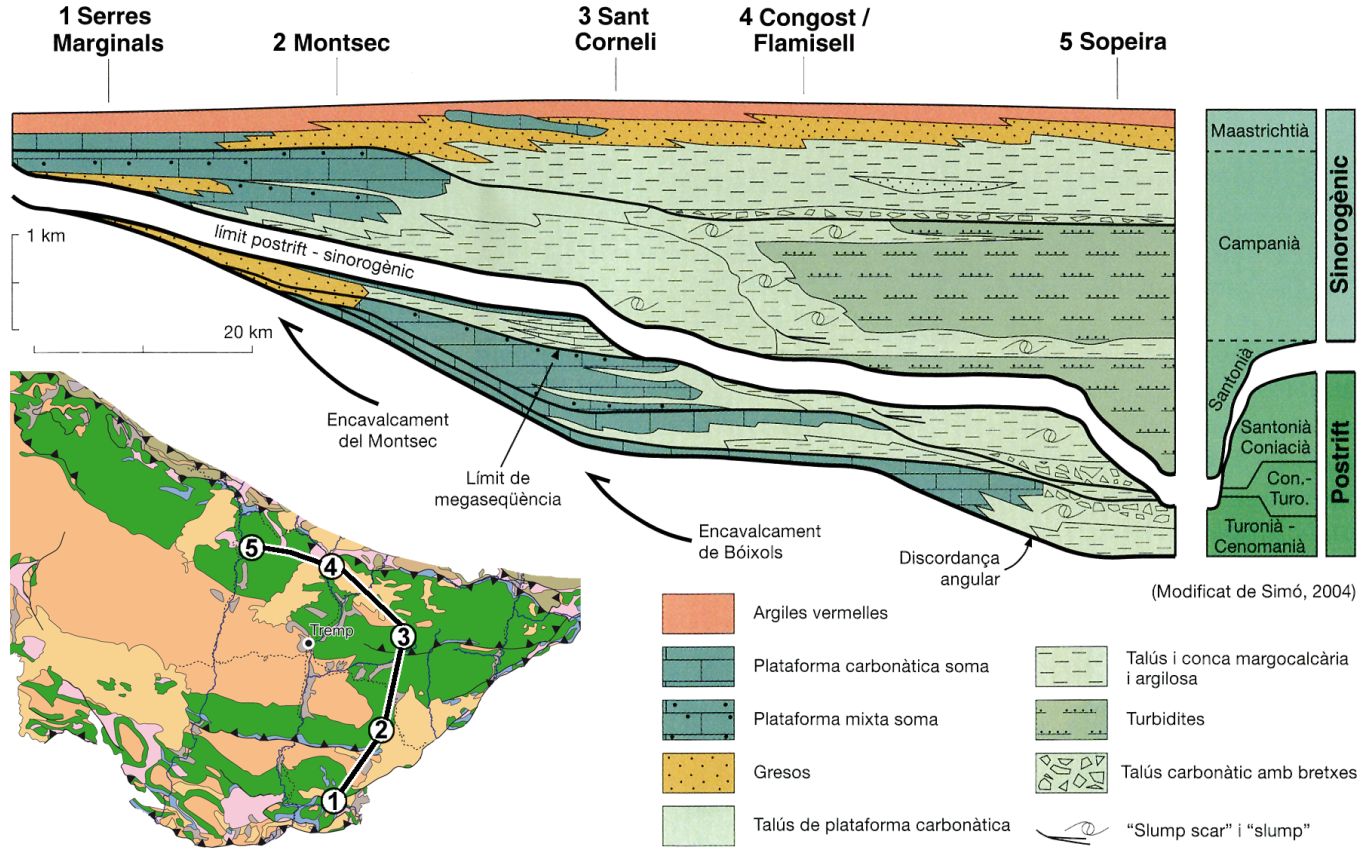
Approaching the end of the Cretaceous, the basin became almost filled-in with deltaic detritic sediments and, at the end, a general continental regime installed.

• Geological map of central-eastern South Pyrenees with indication of the main overthrusting sheets and location of the cross section, palaeogeographical map of the Pyrenean Basin during the Late Cretaceous, cross section of the southern Pyrenees (ECOR's profile), and cross section of the South Pyrenean Basin during the Late Cretaceous.

Composite and modified after several figures from ***'Roca, A., Miranda, J. (eds). 2010. Atles geològic de Catalunya. Institut Geològic de Catalunya, Institut Cartogràfic de Catalunya, Generalitat de Catalunya, Barcelona, 463 pp.'***







(Modificat de Simó, 2004)

RIDE BELLATERRA – CELLERS

Our field trip starts in Bellaterra, near **Sabadell**, follows westwards the motorway AP7 to **Martorell** and continues north-westwards the A2, to **Igualada** and **Cervera**. Then, continues north-westwards the road C-352 to **Agramunt** and the C-74 to **Artesa de Segre**, where it joins the C-26 to **Cubells**. After visiting STOP 1, Serra d'Arquells, arrives to **Camarasa** by a local road. There, joins road C-13 to Camarasa Dam and Clot de Vall-llobar, with STOP 2 in between, continuing to La Baronia de Sant Oïsme, Pas de Terradets and, finally, **Cellers**.

We shall cross all the continental Miocene deposits of the Vallès Depression, the Vallès fault, and the metamorphic Palaeozoic and the marine Triassic overthrusting the Palaeocene and the Eocene. Montserrat, an impressive mountain formed by Eocene conglomerates, will appear to our view at the right hand. We shall cross the Eocene and the Oligocene of the **Ebre Basin** and, at **Artesa de Segre**, we shall reach the southernmost reliefs of the Pyrenees, the **Serres Marginals**. Crossing the Jurassic and the Upper Cretaceous of these last we shall arrive to the Palaeocene and Eocene of the **Conca d'Àger**. Then, through the Pas de Terradets, we shall cross the **Serra de Montsec** until **Cellers** in the **Conca de Tremp**.

STOP 1.- SERRA D'ARQUELLS

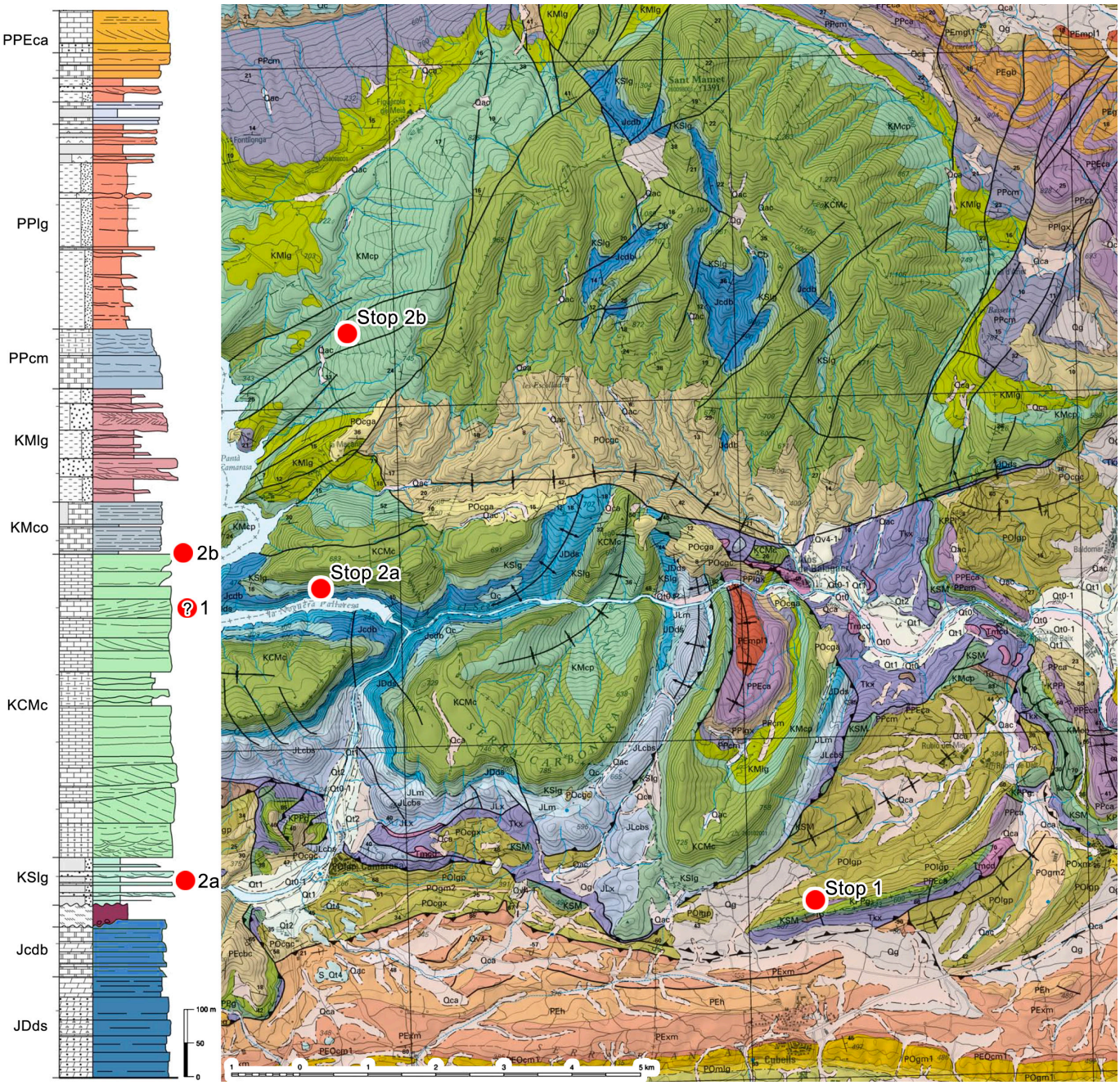
Serra d'Arquells, located 700 m North of Cubells is the southernmost edge of the Serres Marginals. The Upper Cretaceous there is very thin, only the uppermost part is represented, and lies directly on the Triassic. Identified rudist species correspond to the upper Campanian: *Hippurites radiosus* des Moulins, *Hippuritella lapeirousei* (Goldfuss), *Biradiolites lameracensis* Toucas, *Lapeirousia* sp. and *Praeradiolites boucheroni* Toucas.

STOP 2.- ROAD C-13

From the Camarasa Dam, the road crosses the margin of the Serra de Sant Mamet, another element of the Serres Marginals. The marine Upper Cretaceous is here much thicker than in the former Serra d'Arquells; most of the Campanian is represented, and lies over the Jurassic. On top, freshwater limestones and marls with charophytes and ostracods are followed by marls and sandstones with reptile dinosaurs remains.

STOP 2a, at km 48, in Rendisclera de La Maçana, shows the lower rudist horizon of the lower Campanian. The following species have been reported: *Hippurites vidali* Matheron, *Hippuritella variabilis* (Douvillé), *Hippuritella* sp., *Vaccinites archiaci* (Munier-Chalmas), *Biradiolites leychertensis* Toucas, *B. siracensis* Toucas, and *Praeradiolites subtoucasi* Toucas.

STOP 2b, at km 55, in Clot de Vall-llobar, shows the boundary between the last marine limestones of the upper Campanian and the continental Upper Cretaceous. Rudist species identified in the former include: *Hippurites radiosus* des Moulins, *Hippuritella lapeirousei* (Goldfuss), *Biradiolites chaperi* Toucas, *Praeradiolites boucheroni* Toucas, and *Radiolitella pulchellus* (Vidal).



- Stratigraphic column and geological map, with indication of STOPS 1 and 2.

Stratigraphic column from ***'Mapa Geològic 1:25000. Figuerola de Meià 328-1-1 (65-25). 2004'***.

Geological map from ***'Mapa geològic comarcal de Catalunya 1:50000. 23 Noguera. 2006'***. Both maps edited by ***'Institut Geològic de Catalunya, Institut Cartogràfic de Catalunya, Generalitat de Catalunya, Barcelona'***.

All the published geological maps of Catalonia may be consulted or downloaded through the web page <http://www.icgc.cat>

RIDE CELLERS – MONTSEC – CELLERS

Thursday's field trip starts in **Cellers**, at the southern margin of **Conca de Tremp**, and follows southwards the road C-13 crossing the **Serra de Montsec** through the **Pas de Terradets** until the **Conca d'Àger**; then, joining the road C-12 until **Àger**. A mountain road climbs up northwards to the top of the Montsec (**Sant Alís**), with STOP 3 in **Montsec de Pedroneta** and STOP 4 in **Coll d'Ares** on the top. The mountain road continues northwards descending to the **Conca de Tremp** and joining, close to Ermita de La Fabregada, the W-E road from Alçamora (in Noguera Ribagorçana valley) to Cellers (in the Noguera Pallaresa valley), continues eastwards until **Moror**, STOP 5. At the end, following eastwards the road LV-9124 until Guardia de Tremp, it joins the road C-13, 3 km north of **Cellers**.

From the Maastrichtian red continental "Garumnian" facies of the Tremp Formation we shall cross down section all the Mesozoic of **Serra de Montsec**: Upper Cretaceous, Lower Cretaceous, Jurassic, and the overthrusting surface, at **Pas de Terradets**. We shall drive along the Palaeogene in **Conca d'Àger** and again, up section, the overthrusting surface and all the Mesozoic of the **Serra de Montsec**. At the end, the upper part of the Tremp Formation and the marine Palaeogene of the **Conca de Tremp** will be crossed.

STOP 3.- MONTSEC DE PEDRONETA

STOP 3a, rudist bearing limestones crop out at the mountain road to Sant Alís, at an altitude of 1,210 m. The following species, attributed to the upper Turonian were identified: *Hippurites resectus* Defrance, *Vaccinites petrocoriensis* Douvillé, *V. rousseli* Douvillé, and *Praeradiolites pailletei* (d'Orbigny).

Some meters up in the section, another rudist rich horizon appears slightly above the road. Identified species correspond to the Coniacian: *Hippurites socialis* Douvillé, *Hippuritella* sp. gr. *toucasi* d'Orbigny, *Vaccinites moulinsi* d'Hombres-Firmas, *Radiolites angeiodes* Lamarck, *R. radiosus* d'Orbigny, *R. vallispetrosae* Astre, *Biradiolites canaliculatus* d'Orbigny, and *Praeradiolites requieni* d'Hombres-Firmas. On top of this horizon, there are cross bedded calcarenites followed up section by lower Santonian rudist bearing limestones (La Cova limestones).

STOP 3b, at an altitude of 1,240 m, a road bifurcation to the W run to the fields of Pedroneta, exploited on the upper Santonian marls (Font de les Bagasses clays and marls). Just below the fields, the upper horizons of the lower Santonian limestones generously display their rudist fauna: *Hippurites matheroni* Douvillé, *H. praecessor* Douvillé, *Vaccinites beaussetensis* Toucas, *Radiolites laciniatus* Vidal, *R. radiosus* d'Orbigny, *R. sauvagesi* (d'Hombres-Firmas), *R. squamosus* d'Orbigny, *B. angulosissimus* Toucas, *B. canaliculatus* d'Orbigny, and *Fossulites undaesaltus* Astre.

STOP 3c, the marl interval (Font de les Bagasses clays and marls) measures up to 350 m in thickness

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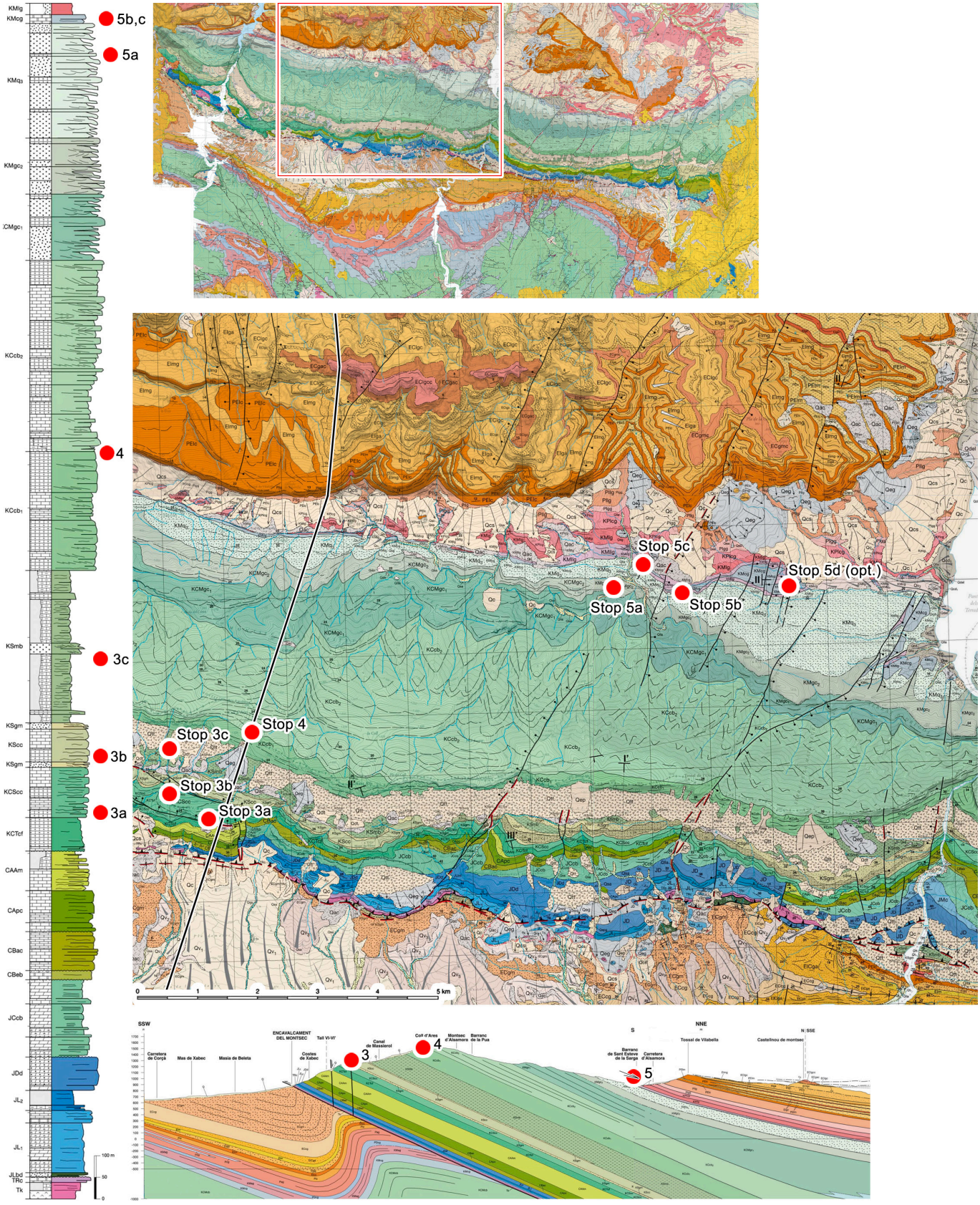
• Geological map of Serra de Montsec, detail of the map, stratigraphical column, and cross section, with indication of STOPS 3 to 5.

Composite geological map from ***'Mapa Geològic 1:25000, sheets: 289-1-1 (63-23) Benavarri / 289-2-1 (64-23) el Pont de Montanyana. 2010; 289-1-2 (63-24) Calladrons / 289-2-2 (64-24) Sant Esteve de la Sarga. 2007; 327-2-1 (64-25) Àger.2008; 290-1-1 (65-23) Vilamitjana. 2004; 290-1-2 (65-24) Llimiana. 2003; 328-1-1 (65-25) Figuerola de Meià. 2004; 290-2-1 (66-23) Isona. 2001; 290-2-2 (66-24) San Salvador de Toló. 2002; and 328-2-1 (66-25) Vilanova de Meià.2007'***.

Detail of the composite map from ***'Mapa Geològic 1:25000, sheets: 289-1-1 (63-23) Benavarri / 289-2-1 (64-23) el Pont de Montanyana. 2010; 289-1-2 (63-24) Calladrons / 289-2-2 (64-24) Sant Esteve de la Sarga. 2007; 290-1-1 (65-23) Vilamitjana. 2004; and 290-1-2 (65-24) Llimiana. 2003'***.

Stratigraphic column from ***'Mapa Geològic 1:25000, sheet 289-1-2 (63-24) Calladrons / 289-2-2 (64-24) Sant Esteve de la Sarga. 2007'***.



Composite cross section from ***'Mapa Geològic 1:25000, sheets: 289-1-1 (63-23) Benavarri / 289-2-1 (64-23) el Pont de Montanyana. 2010; 289-1-2 (63-24) Calladrons / 289-2-2 (64-24) Sant Esteve de la Sarga. 2007'***. All edited by ***'Institut Geològic de Catalunya, Institut Cartogràfic de Catalunya, Generalitat de Catalunya, Barcelona'***.

at Montsec de Pedroneta. Some marly limestone beds containing highly silicified radiolitids occur at the lower part and, 80 m over its base, open cluster reefs of corals, sponges, and rudists in a marly matrix developed. The following rudist species, attributed to the upper Santonian, were identified within this interval: *Hippurites canaliculatus* Rolland du Roquan, *H. microstylus* Douvillé, *H.* cf. *socialis* Douvillé, *H. turgidus* Rolland du Roquan, *Hippuritella maestrei* (Vidal), *H. sulcatissima* Douvillé, *Vaccinites galloprovincialis* Matheron, *Radiolites angeiodes* Lamarck, *Biradiolites acuticostatus* (d'Orbigny), *B. angulosissimus* Toucas, *B. carezi* Toucas, *B. ibericus* (Vidal), *Praeradiolites caderensis* Toucas, *P. plicatus* Lajard, Negrel & Toulouzan, *P. toucasi* (d'Orbigny), *Sphaerulites boreaui* Toucas, *Apricardia* sp., *Monopleura montsecana* Vidal, *M. minuta* Pons, *non* Vidal, *Plagioptychus toucasi* (d'Orbigny), and *Plagioptychus* sp.

Around the 130 m of this unit, limestone beds are more conspicuous and at about their 180 m some sandstone beds intercalate. The last 150 m are partially covered.

STOP 4.- COLL D'ARES

STOP 4, back to the main mountain road and continuing upwards, we shall reach the highest point of the Montsec d'Ares at Sant Alís and hopefully enjoy a spectacular view of the landscape and geology both Northwards and Southwards.

At Coll d'Ares, a lower Campanian bed of the Terradets limestones furnishes the following rudist species: *Hippurites vidali* Matheron, *Hippuritella variabilis* (Douvillé), *Vaccinites archiaci* (Munier-Chalmas), *Biradiolites leychertensis* Toucas, *B. siracensis* Toucas, *Lapeirousia* sp., and *Praeradiolites subtoucasi* Toucas.

No more stops in higher beds of the Terradets limestones nor of the overlaying Areny Sandstones Formation equivalent are scheduled, but we shall notice the increasingly inputs of fine to medium grain terrigenous (sands).

STOP 5.- MOROR

STOP 5, at Moror, a path road bifurcation running southwards, across the cultivated field area arriving to the outcrops of the uppermost Campanian and lower Maastrichtian.

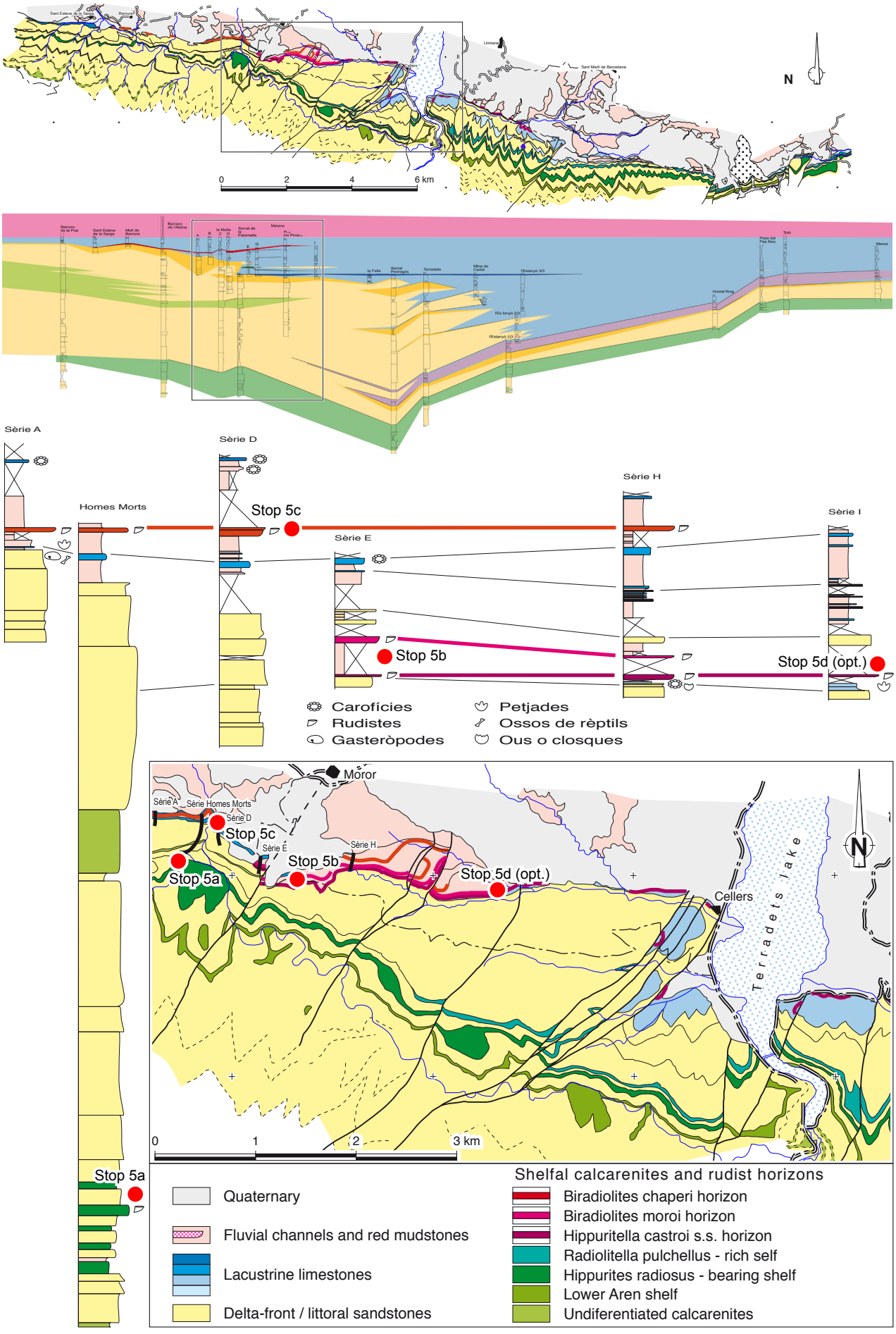
At STOP 5a, we shall see the last rudist carbonate platform of the Serra de Montsec, with: *Hippurites radiosus* des Moulins and *Hippuritella lapeirousei* (Goldfuss).

At STOP 5b and STOP 5c, we shall see the three successive lower Maastrichtian rudist horizons developed on the lower part (gray "Garumnian") of the Tremp Formation: *Hippuritella castroi* s.s., *Biradiolites moroi* [= new. genus *moroi*], and *Biradiolites chaperi* horizons. The following species have been reported: *Hippuritella castroi* (Vidal), *Biradiolites ara* Pons, *Biradiolites chaperi* Toucas, New genus *moroi* (Vidal), *Praeradiolites boucheroni* Toucas, *Monopleura moroi* (Vidal), and *Monopleura* sp.

We shall return to the main road at Moror and continue to **Cellers**. If it is not too late and you are not too tired, an optional STOP 5d offers a beautiful outcrop of the *Hippuritella castroi* s.s. horizon.

• Geological map along the southern limb of the Tremp Basin syncline, cross section, correlated stratigraphical sections, and detailed map of the Cellers-Moror area, with indication of STOP 5a-d.

The cross section is unpublished, the maps and correlated stratigraphical sections are from ***'Pons, J.M. and Vicens, E. 2006. Rudist Bivalves in the Pyrenean Upper Cretaceous. Field Trip guide. International Congress on Bivalvia. Organisms Diversity & Evolution 6, Electronic Supplement 16, part 3: 1-18 (2006) < http://www.senckenberg.de/odes/06-16pt3.pdf>***


N
0 2 4 6 km
Sèrie A
Sèrie D
Homes Morts
Stop 5c
Sèrie E
Sèrie H
Sèrie I
Stop 5b
Stop 5d (opt.)
Carofícies
Rudistes
Gasteròpodes
Petjades
Ossos de rèptils
Ous o closques
Moror
Sèrie A
Sèrie Homes Morts
Sèrie D
Stop 5c
Sèrie E
Sèrie H
Stop 5b
Stop 5a
Stop 5d (opt.)
Cellers
Terradets lake
N
0 1 2 3 km
Stop 5a
Quaternary
Fluvial channels and red mudstones
Lacustrine limestones
Delta-front / littoral sandstones
Shelfal calcarenites and rudist horizons
Biradiolites chaperi horizon
Biradiolites moroi horizon
Hippuritella castroi s.s. horizon
Radiolitella pulchellus - rich self
Hippurites radiosus - bearing shelf
Lower Aren shelf
Undiferentiated calcarenites

RIDE CELLERS – LES COLLADES DE BASTURS

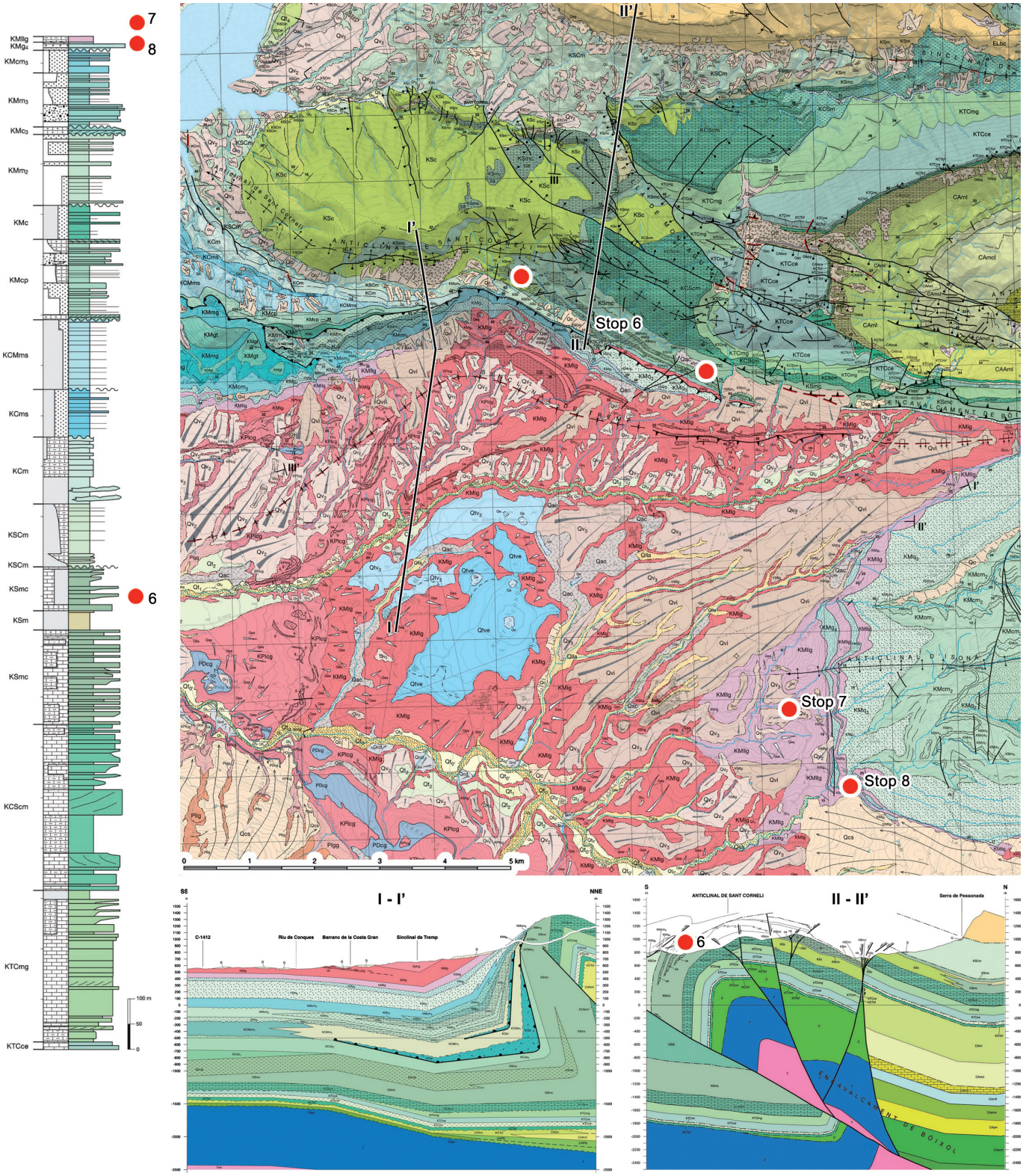
Friday's field trip starts in **Cellers**, at the southern margin of the **Conca de Tremp**, and follows northwards the road C-13 until **Tremp**, in the centre of the Conca. Then, joining the road C-74, follows eastwards until **Isona**. It continues 3 km north-eastwards through the road C-363 until Ermita de La Posa and joins a local road to **Abella de la Conca**. Approximately 0.5 km before the village, a mountain road runs westwards to Cal Borrell and Collada Pelosa, where "STOP" 6 starts.

We will wander on rudists up and down along four km. Don't forget to take with you your lunch pack and drinks; lunch break will be on the outcrop, far from the vehicles.

STOP 6.- LES COLLADES DE BASTURS

At Collades de Basturs, a Santonian mixed siliciclastic-carbonate succession is very well exposed. Two proximal-distal gradients are indicated, recording two styles of stratigraphical development upon relative sea-level change. In the eastern sector, the Collades Member consists of a succession of neritic marls with four intercalated intervals of shallow-water limestones. Each carbonate interval consists of stacked upward shoaling cycles interpreted as parasequences. From bottom to top, most parasequences consist of a coral-sponge-rudist bioconstruction, a rudist biostrome, and bioclastic limestones. In the western sector, the Collades Member consists of hummocky cross-laminated to bioturbated sandy calcarenites, of neritic marls, and of relatively thin intervals of coral-sponge-rudist limestones.

Rudist species identified indicate the lower Santonian: *Hippurites matheroni* Douvillé, *H. microstylus* Douvillé, *H. praecessor* Douvillé, *H. socialis* Douvillé, *H. sublaevis* Matheron, *Hippuritella maestrei* (Vidal), *H. toucasi* d'Orbigny, *Vaccinites beaussetensis* Toucas, *V. galloprovincialis* (Matheron), *V. giganteus major* Toucas, *V. zurcheri* Toucas, *Radiolites angeiodes* Lamarck, *R. squamosus* d'Orbigny, *R. vallispetrosae* Astre, *Biradiolites acuticostatus* (d'Orbigny), *B. angulosissimus* Toucas, *B. beaussetensis* Toucas, *B. canaliculatus* d'Orbigny, *B. carezi* Toucas, *Bournonia excavata* (d'Orbigny), *Praeradiolites caderensis* Toucas, *P. plicatus* Lajard, Negrel & Toulouzan, *P. toucasi* (d'Orbigny), *Apricardia* sp., *Bayleia* sp., Monopleuridae indet., *Plagioptychus aguilloni* (d'Orbigny), and *P. toucasi* Matheron.



• Geological map, stratigraphical section, and cross sections of the Sant Corneli – Isona area, with indication of STOPS 6 to 8.

Composite geological map from ***'Mapa Geològic 1:25000, sheets: 252-1-2 (65-22) Tremp. 2009; 290-1-1 (65-23) Vilamitjana. 2004; 252-2-2 (66-22) Aramunt. 2010; 290-2-1 (66-23) Isona. 2001'***.

Stratigraphical column from ***'Mapa Geològic 1:25000, sheets: 252-2-2 (66-22) Aramunt. 2010'***.

Cross sections I-I' and II-II' from ***'Mapa Geològic 1:25000, sheets: 290-2-1 (66-23) Isona. 2001 and 252-2-2 (66-22) Aramunt. 2010',*** respectively.

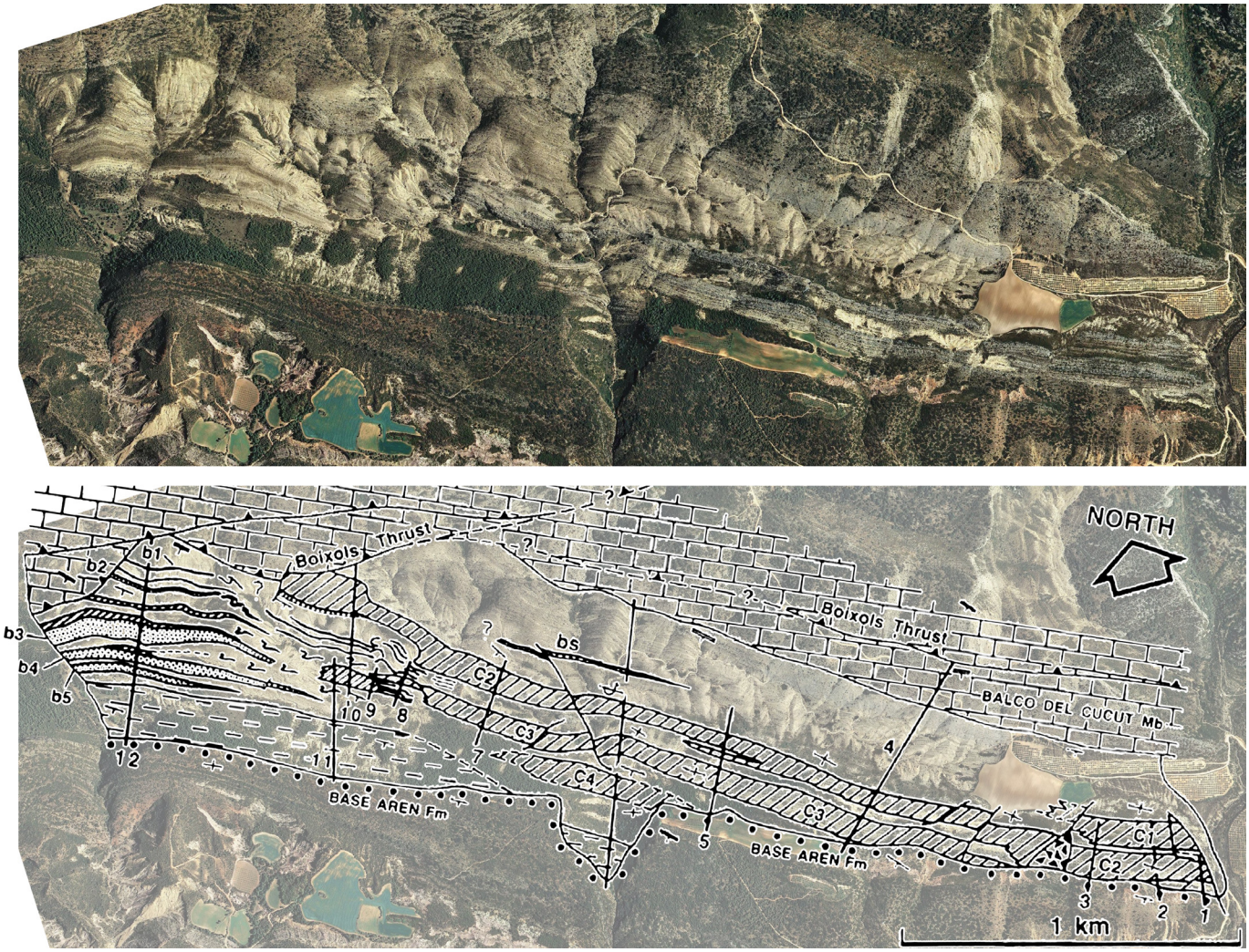


Fig. 4. Geological map of Collades de Bastus, drawn from aerial photographsand field data. Lines numbered 1 to 12 indicate measured sections. The substratum of the Collades Member is a succession mainly of coral-rudist bioconstructions and bioclastic limestones (Balco del Cucut Member of Montagut Limestone Formation). In the eastern part of outcrop, the Collades Member consists of neritic marls with four intercalated intervals (C1 to C4) of shallow-water limestones. Towards west, carbonate intervals C1, C2 and C3 grade into and interfinger with neritic marls. In the western part of outcrop, the Collades Member consists of neritic marls with five intercalated bedsets (b1 to b5) of sandy calcarenites, and with relatively thin intervals of shallow-water limestones. Between the eastern and western part of outcrop, the marls are deformed into open folds and chevron folds with steeply-dipping axes. The Collades Member is overlain by marls from deep neritic to upper bathyal environments (Podega Member). Both the Podega Member and the Collades Member are overlain along an angular unconformity by an onlapping succession of shore zone sandstones of the Aren Formation (Maastrichtian).

- Aerial photograph and geological map of Collades de Basturs.

Aerial photograph from ***'Institut Cartogràfic de Catalunya' <http://www.icgc.cat>***.

Geological map and figure caption from ***'Sanders, D. and Pons, J.M. 2001. Stratigraphic Architecture of a Santonian Mixed Siliciclastic-Carbonate Succession (Catalonian Pyrenees, Spain). Facies, 44: 105-136'***.

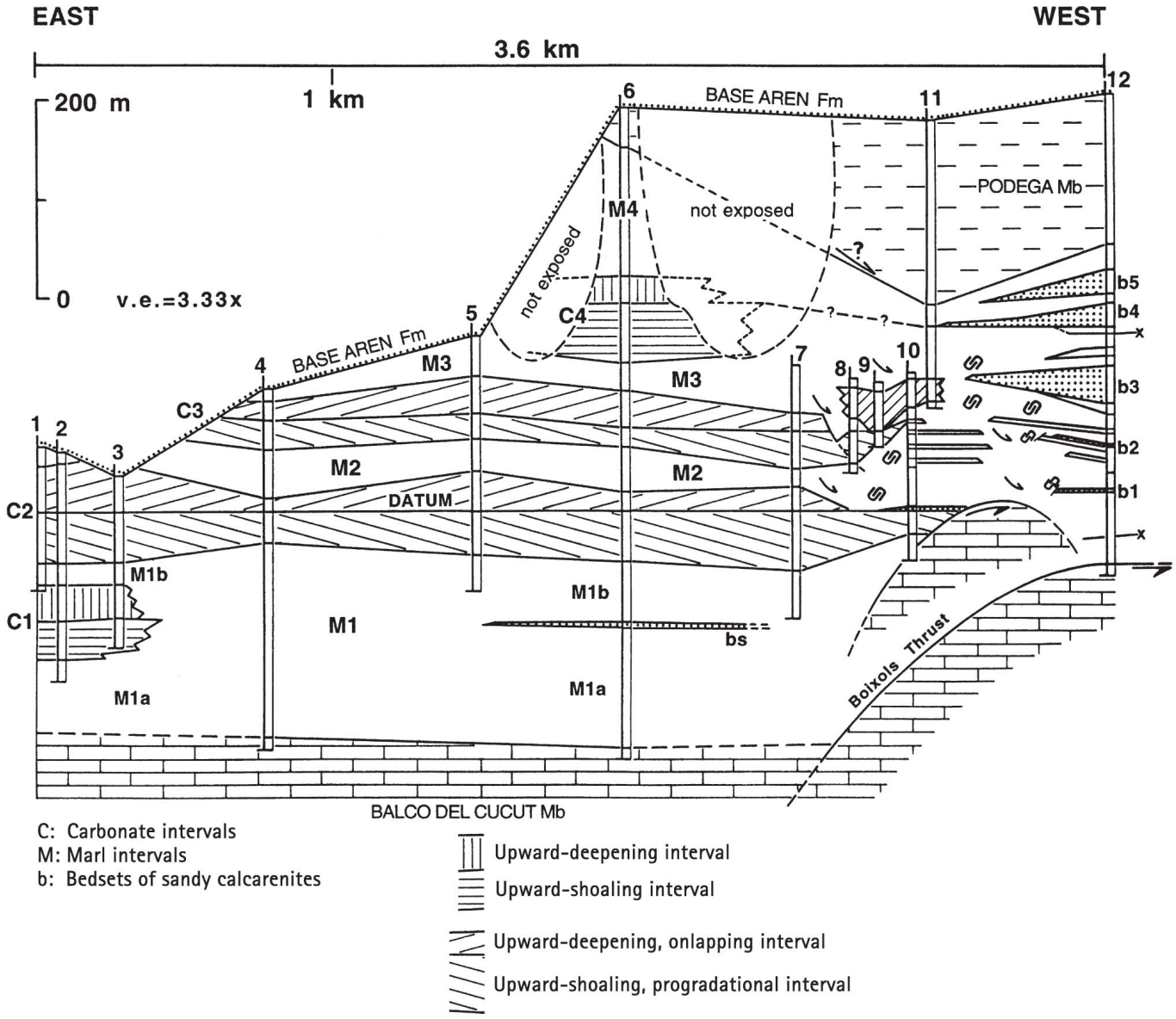


Fig. 5. Correlated sections along Collades de Bastus. Datum is a “level of maximum shoaling” within carbonate interval C2. The Balco del Cucut Member vertically develops into an interval M1 of neritic marls. Because of carbonate interval C1 and a bedset (bs) of sandy calcarenites, a lower marl interval M1a and an upper interval M1b can locally be distinguished. Up-section, the eastern part of the Collades Member consists of carbonate intervals C2 to C4 and neritic marl intervals M2 to M4. Carbonate interval C4 is overlain by neritic marls M4 that, up-section, grade into deep-water marls of the Podega Member. Each carbonate interval consists of a lower part that records shoaling and progradation (intervals C2, C3), or shoaling at least by aggradation (intervals C1, C4; limited exposure). The upper part of each carbonate interval records deepening and retrogradation (intervals C2, C3), or at least progressivedeepening up-section (intervals C1, C4; limited exposure). At sections 8 to 11, a body of shallow-water limestones is present that is embedded within neritic marls. In the western part of outcrop, the Collades Member consists of neritic marls, thin tongues of shallow-water limestones and five bedsets (b1 to b5) mainly of sandy calcarenites. Both the Podega Member and the ColladesMember are overlain along an angular unconformity by shore zone arenites of the Aren Formation.

• Correlated sections along Collades de Basturs.

Figure and figure caption from ***‘Sanders, D. and Pons, J.M. 2001. Stratigraphic Architecture of a Santonian Mixed Siliciclastic-Carbonate Succession (Catalonian Pyrenees, Spain). Facies, 44: 105-136’***.

Facies	Main characteristics	Sedimentary	Fossils	Interpretation
Bioclastic floatstones to rudstones	Angular, large bioclasts	Shelter pores	Corals, rudists, sponges red algae	Deposition during high-energy events
	Well-rounded, large bioclasts	Crudely laminated subparallel to bedding	Corals, rudists, sponges	Deposition close to within fairweather wave base
Bioturbated bioclastic packstones to grainstones	Bioclasts mainly from rudists and corals. Benthic foraminifera	Softground-bioturbated	Rudists, corals, skeletal sponges, echinoderms, benthic foraminifera	Shallow subtidal environment of moderate water energy
Laminated bioclastic grainstones	Rounded, micrite-rimmed rudists fragments	Lamination subparallel to bedding, keystone vugs, shelter pores	Benthic foraminifera	Depositon close to within fairweather wave base
	Bioclastic silt to sand, benthic foraminifera	Lamination subparallel to bedding, inclined cross-laminasets, hummocky cross-laminasets, pot casts at bed base	Benthic foraminifera, *Biradiolites*, *Praeradiolites*, *Hippurites maestrei* *H. microstylus*	Storm beds deposited in a lower shoreface to inner shelf environment
Sandy calcarenites	Quartz-sandy to quartz-gravelly bioclastic grainstones to packstones	Sets of plane to wavy beds with hummocky cross-lamination, inclined cross lamination, and subparallel lamination	Benthic foraminifera	Sandy-gravelly bioclastic limestones deposited in a shoreface envrionment
Rudist limestones	Sheets of floatstone to bafflestone to clusterstone of rudists	Crudely defined bedding (locally) to 'massive'	*Vaccinites* spp., *Hippurites* ex gr. *socialis*,*Radiolites*	Rudist biostromes
Coral-sponge-rudist limestones to marls	Floatstones, rudstones bafflestones, boundstones of corals	Typically thick-bedded to 'massive'	Scleractinians, skeletal sponges, diverse hippuritids and radiolitids, spondylids	Skeletal mounds to level-bottoms mainly of corals, skeletal sponges and rudists
Neritic marls	Bioturbated, clayey to sandy, (micro)bioclastic packstones to wackestones	Nodular to wavy bedded	Benthic foraminifera, solitary corals brachiopods, non-rudist bivalves, ammonites, echinoids, bryozoans	Marls deposited in a neritic environment

Table 1. Summary of main facies of the Collades Member, and their characteristics.

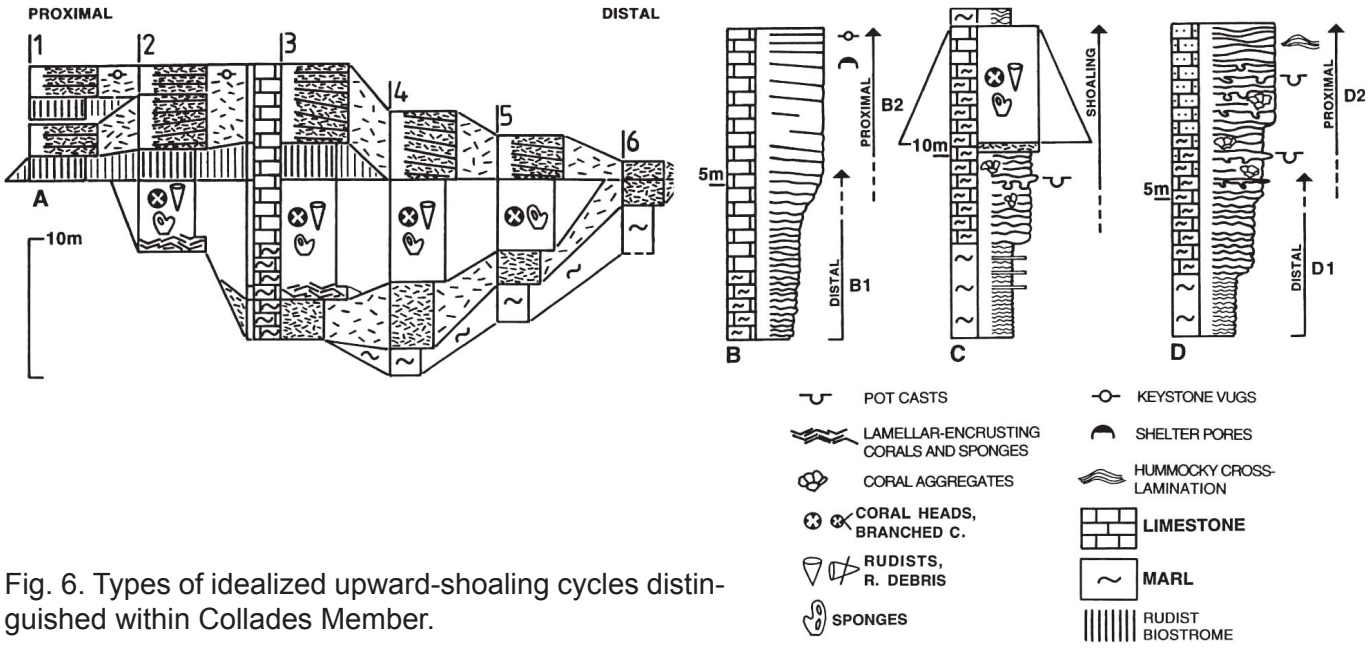


Fig. 6. Types of idealized upward-shoaling cycles distinguished within Collades Member.

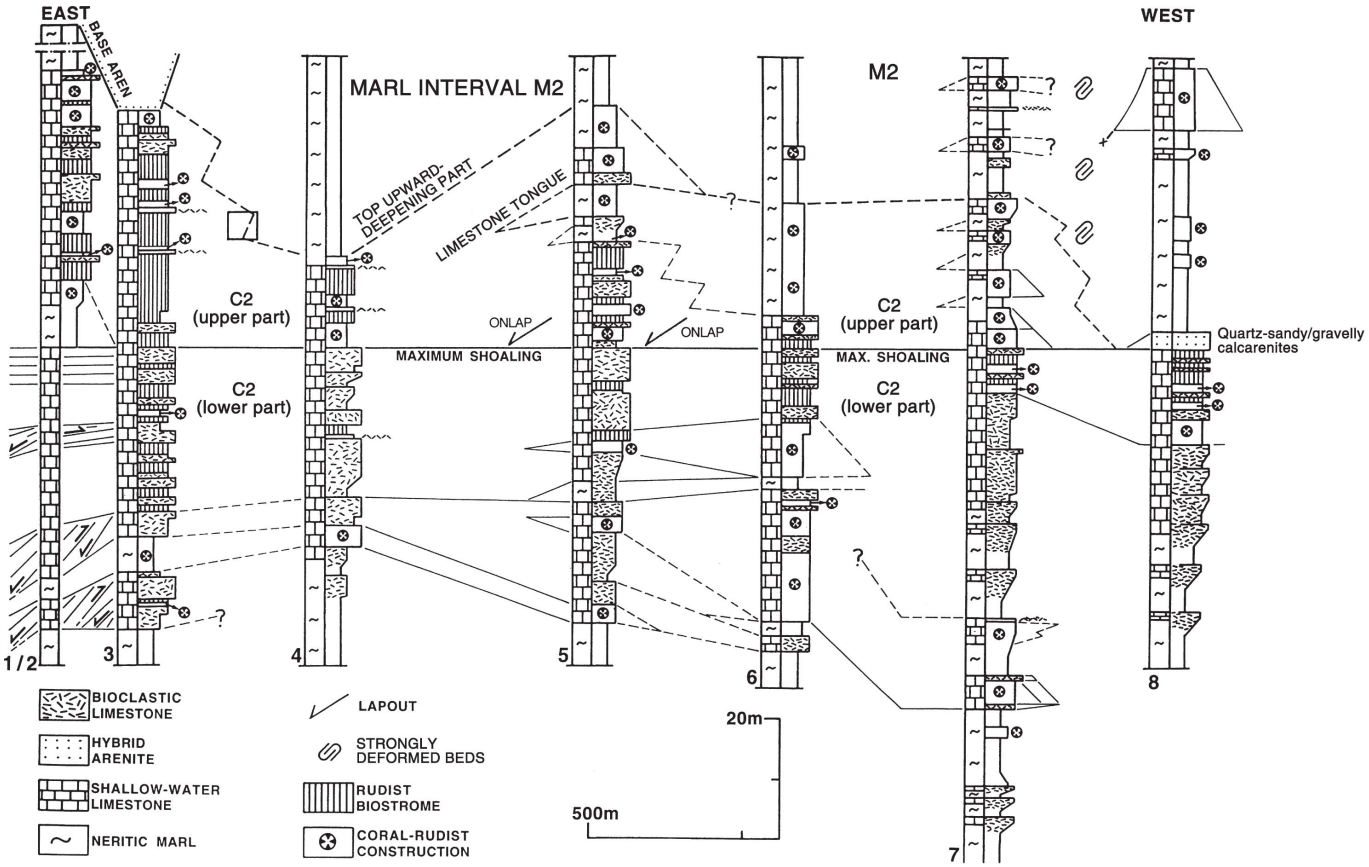


Fig. 9. Sections 1 to 8 across carbonate interval C2. Vertically exaggerated. Up-section the lower part of C2, the thickness of upward-shoaling cycles decreases. Both type A and type B cycles are present (cf. Fig. 6). Near the eastern outcrop limit, intervals of bioclastic limestones consist of bedsets delimited by master bedding surfaces of parallel-oblique to divergent-oblique geometry; the topmost bedset is parallel-bedded. In the upper part of C2, the thickness of type A cycles increases and the bioclastic limestones become marly. The upper part of C2 onlaps at a low angle the lower part of interval C2. In section 8, a rudist biostrome is sharply overlain along an undulated surface by a bedset of quartz-sandy/gravelly calcarenites (see Pl. 18/4). The bedset, in turn, is overlain by marl interval M2. In the area of sections 7 to 8, interval M2 contains sheets of marly coral-sponge-rudist limestones.

• Correlated sections across carbonate interval C2 of Collades Member at Collades de Basturs.

Figure and figure caption from ***'Sanders, D. and Pons, J.M. 2001. Stratigraphic Architecture of a Santonian Mixed Siliciclastic-Carbonate Succession (Catalonian Pyrenees, Spain). Facies, 44: 105-136'***.

• Main facies and types of idealized upward shoaling cycles distinguished within Collades Member at Collades de Basturs.

Figures and figure captions from ***'Sanders, D. and Pons, J.M. 2001. Stratigraphic Architecture of a Santonian Mixed Siliciclastic-Carbonate Succession (Catalonian Pyrenees, Spain). Facies, 44: 105-136'***.

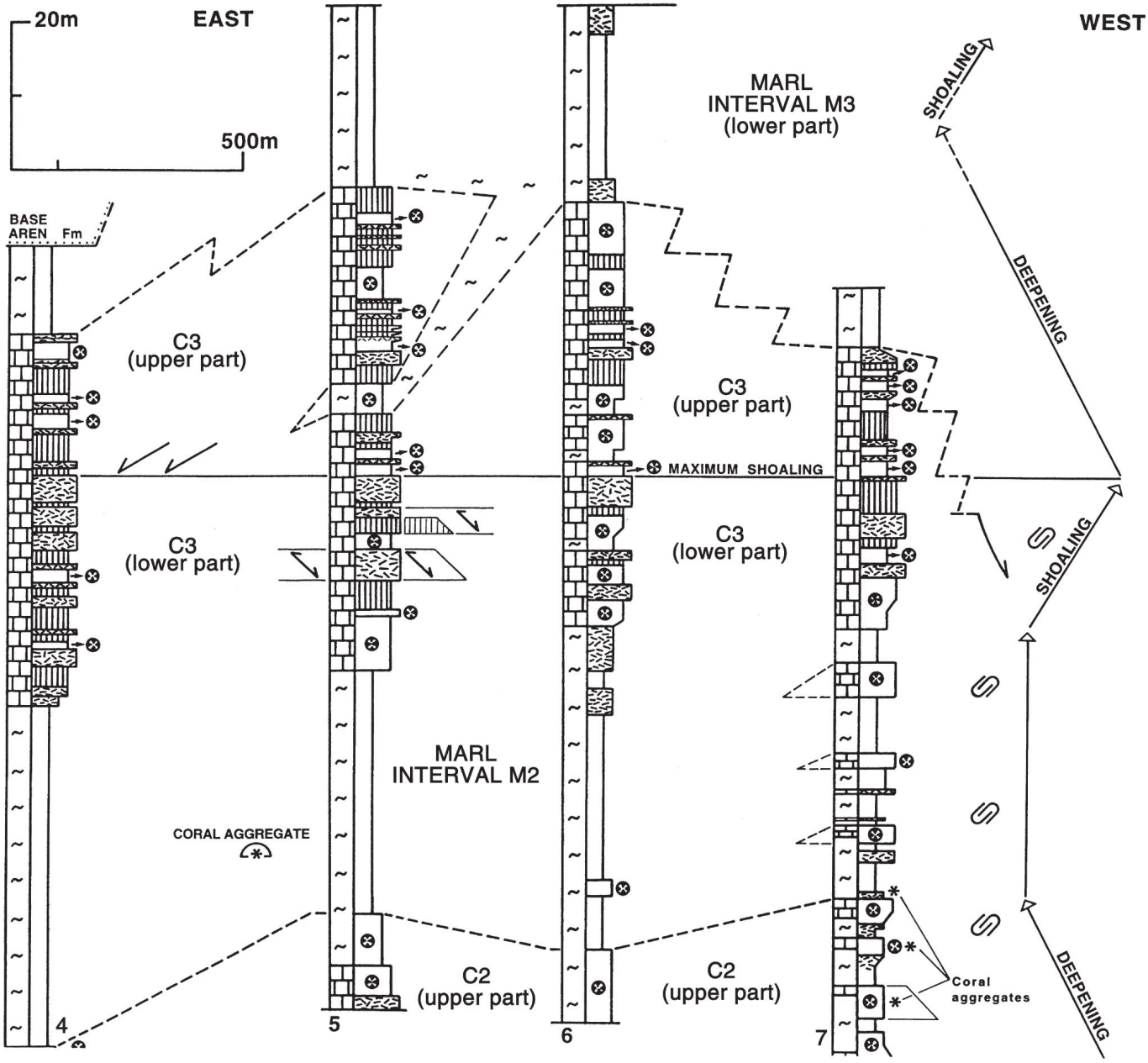


Fig. 11. Sections 4 to 7 across marl interval M2, carbonate interval C3 and marl interval M3. Vertically exaggerated. „Shoaling“ and „deepening“: interpreted development of depositional water depth. Marl interval M2 contains sheets of marly coral-sponge-rudist limestones (section 7), and „coral aggregates“ a few decimeters to, rarely, a few meters in size of coral boundstone. In the middle

part of marl interval M2, no distinct bathymetric trend was recognized. Above, in the lower part of carbonate interval C3, up-section the thickness of type A cycles decreases and the bioclastic limestones become increasingly winnowed. Along section 5, beds within intervals of bioclastic limestones show a westward downlap, and toplap at their up-dip end. The upper part of carbonate interval C3 onlaps, at a low angle, the maximum shoaling horizon. Up-section the upper part of C3, type A cycles thicken, and the bioclastic limestones become marly. In section 6, the topmost interval of bioclastic limestone is the base of carbonate interval C4. Within marl interval M3, no distinct bathymetric trend and no maximum fl ooding interval could be distinguished (dashed line of deepening to shoaling).

• Correlated sections across marl interval M2 of Collades Member at Collades de Basturs.

Figure and figure caption from ***‘Sanders, D. and Pons, J.M. 2001. Stratigraphic Architecture of a Santonian Mixed Siliciclastic-Carbonate Succession (Catalonian Pyrenees, Spain). Facies, 44: 105-136’***.

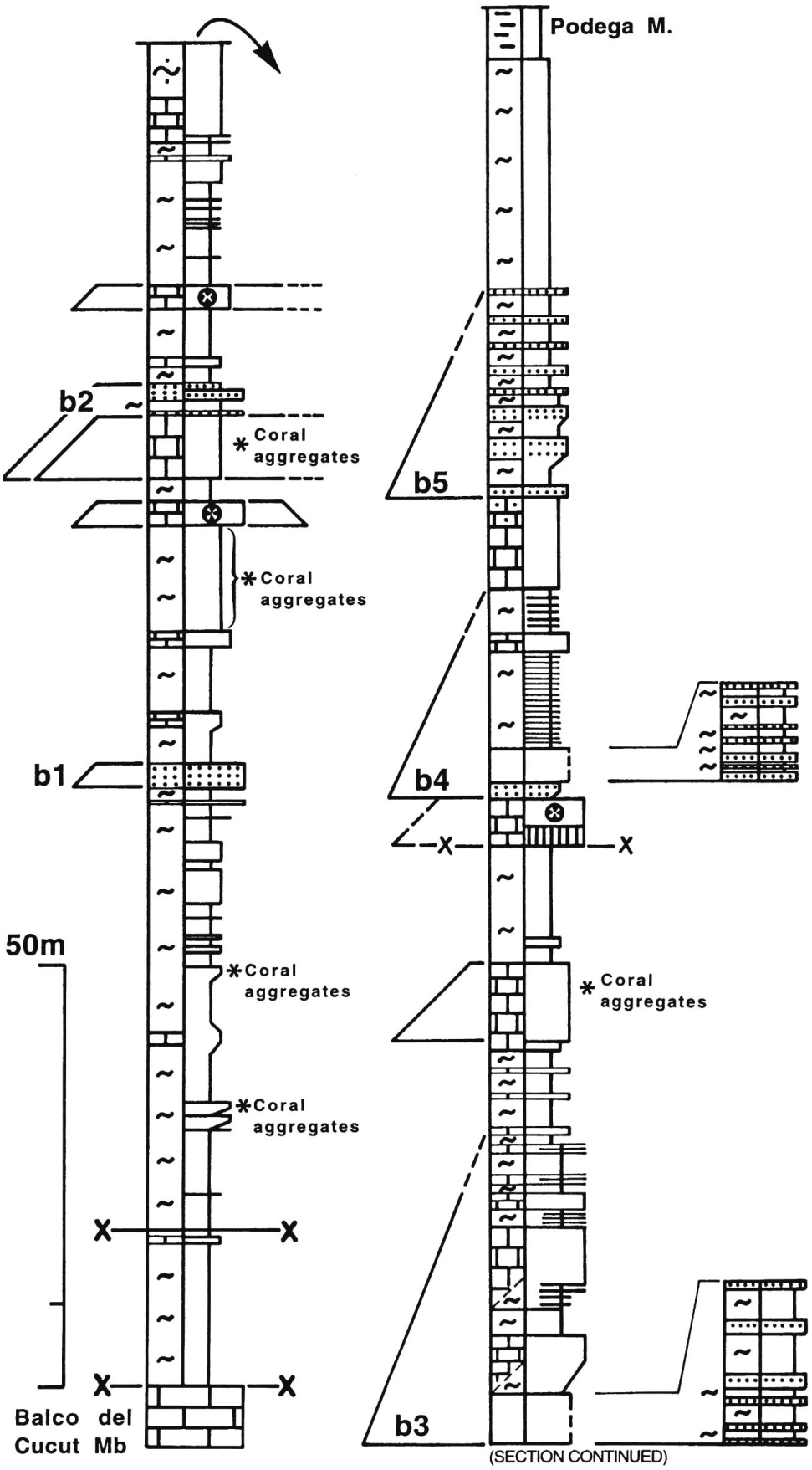


Fig. 15. Section 12 across Collades Member in the western part of outcrop. At its base, the succession is faulted due to the vicinity of splays of the Boixols thrust, and because of Tertiary strike-slip faulting. The triangular apices aside some intervals indicate pinchout as seen in the fi eld and/or on aerial photographs. Here, the succession consists of neritic marls, of sharp-based bedsets (b1 to b5) up to a few tens of meters thick with sandy calcarenites (stippled), and of a few sheets of coral-sponge-rudist limestones to -marls. The coralsponge-rudist limestones and bioclastic limestones with coral aggregates locally are present at the top of type C cycles (Fig. 6). The bedsets b1 and b2 do not show clear-cut cyclicity. The bedsets b3 and b5 are arranged in type D cycles (Fig. 6) that, up-section, become thinner and contain progressively more neritic marls. Bedset b4 consists of beds of sandy calcarenites rhythmically intercalated into neritic marls. Along section 12, with respect to the vertical arrangement of neritic marls and of limestones (coral-sponge-rudist limestones, marly bioclastic limestones) between the bedsets b1 to b5, no clear-cut cyclicity is discerned.

• Section across Collades Member at the western part of Collades de Basturs.

Figure and figure caption from ***'Sanders, D. and Pons, J.M. 2001. Stratigraphic Architecture of a Santonian Mixed Siliciclastic-Carbonate Succession (Catalonian Pyrenees, Spain). Facies, 44: 105-136'***.

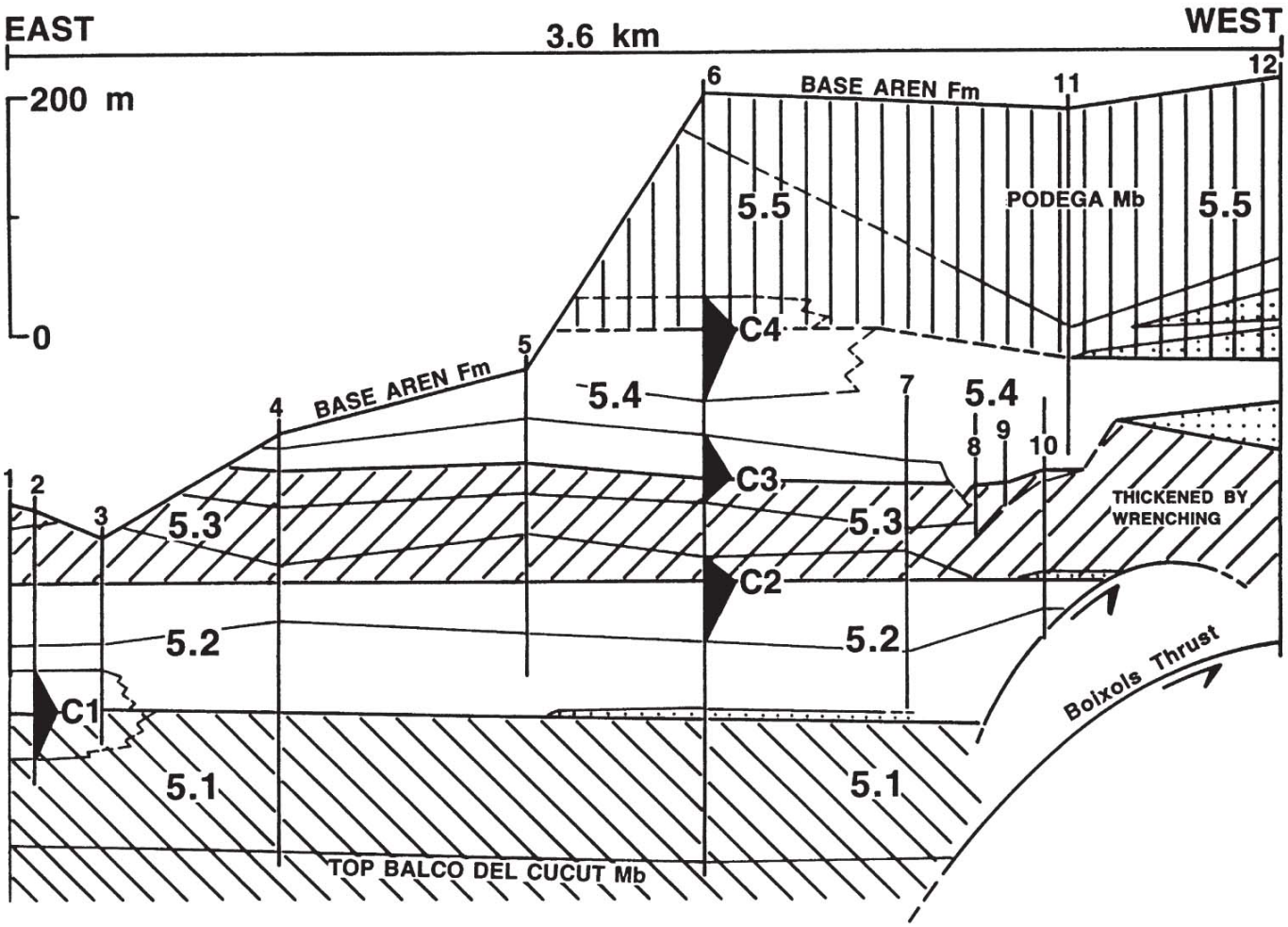


Fig. 16. Sequence stratigraphic interpretation of Collades Member (see also Fig. 5), vertically exaggerated. Carbonate intervals C1 to C4 and major bedsets of sandy calcarenites indicated. Within the Collades Member that here comprises the highstand systems tract of the „Vallcarca-5“ depositional sequence of SIMO (1993), four smaller-scale depositional sequences labelled 5.1 to 5.4 are distinguished. In the western part of outcrop, sequence interpretation is not straightforward. The uppermost sequence 5.5 is a drowning seqence from the topmost part of the Collades Member into overlying marls from deep neritic to upper bathyal environments (Podega Member) (cf. SIMO 1993; SCHLAGER 1998). See text for discussion.

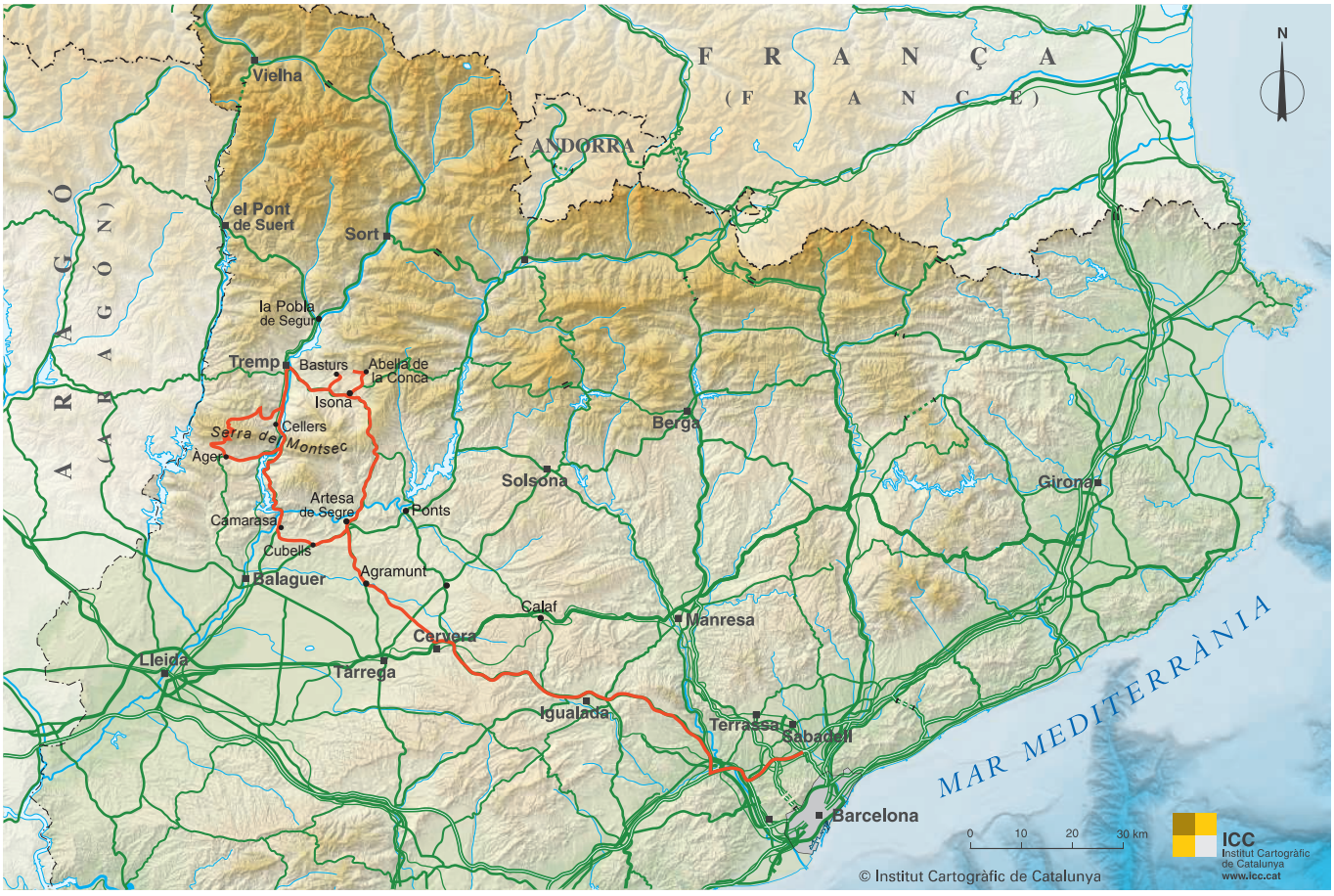
• Sequence stratigraphic interpretation of Collades Member at Collades de Basturs.

Figure and figure caption from ***'Sanders, D. and Pons, J.M. 2001. Stratigraphic Architecture of a Santonian Mixed Siliciclastic-Carbonate Succession (Catalonian Pyrenees, Spain). Facies, 44: 105-136'***. In our opinion, it does not correspond to the "Vallcarga 5" depositional sequence of Simó (1993. Cretaceous carbonate platforms and stratigraphic sequences, south central Pyrenees, Spain. In: Simó, J.A.T., Scott, R,W. and Masse, J.-P. (eds): Cretaceous Carbonate Platforms. Amer. Ass. Petrol. Geol. Mem., 56: 325-342) as indicated, but to the "Sant Corneli 4" one.

RIDE LES COLLADES DE BASTURS – BELLATERRA

After a long (but pleasant, we hope) promenade among rudists, participants join the vehicles 1 km north of **Basturs** and return to **Isona** by local roads. From **Isona** and along the road C-74 to **Artesa de Segre**, an optional STOP 7 is possible with a very slight deviation from the main road, allowing the observation of the *Hippuritella castroi* s.s. horizon with abundant specimens of *H. castroi* occurring; another optional STOP 8, at km 37, shows the *Radiolitella pulchellus* horizon; the Coll de Comiols offers a panoramic view of the **Conca de Tremp**.

From **Artesa de Segre**, the same itinerary of the first day, but reversed, is followed: C-74 to **Agramunt**, C-352 to **Cervera**, A2 to **Igualada** and **Martorell**, and AP7 to **Bellaterra**.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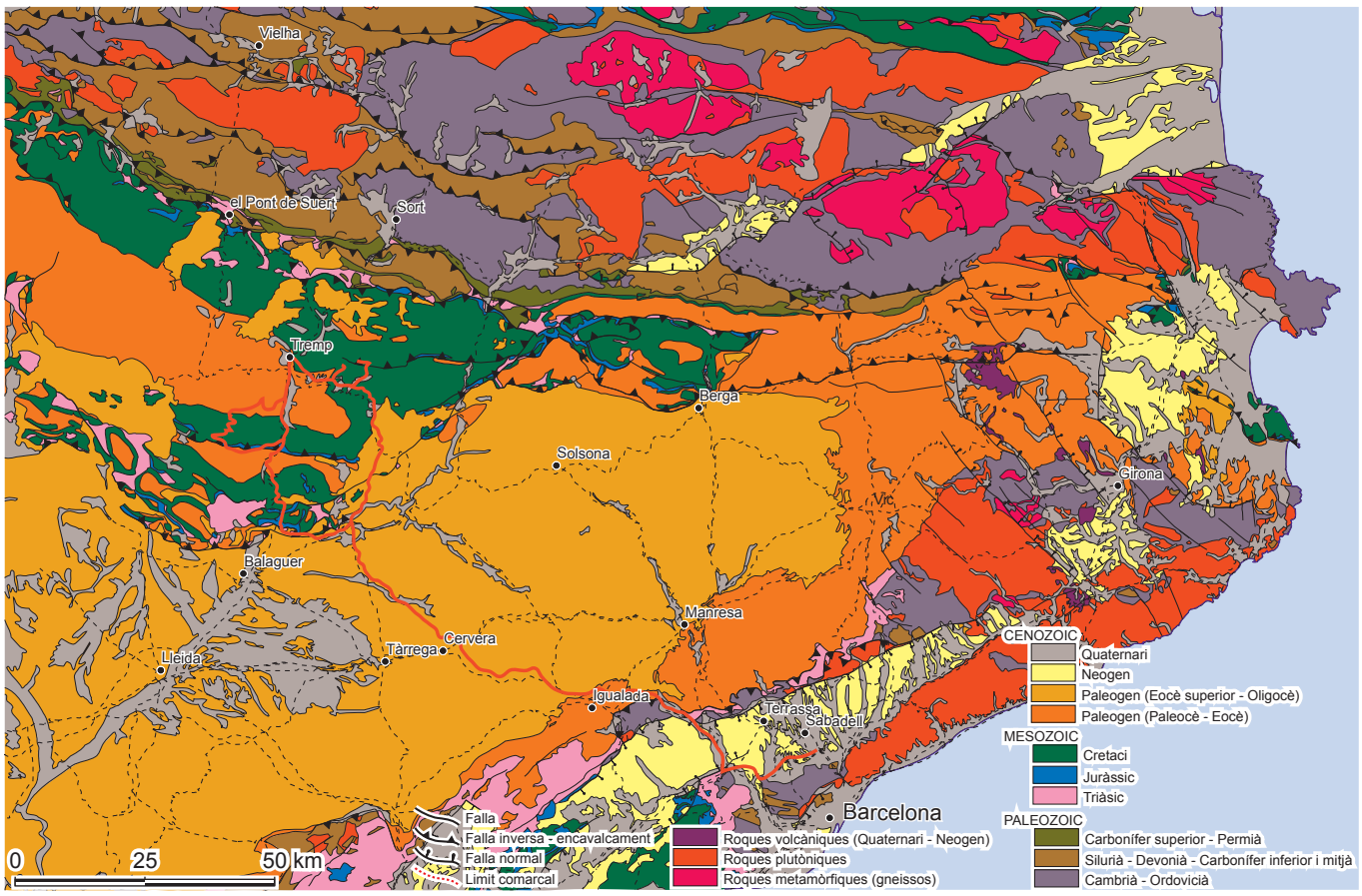
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Roques metamòrfiques (gneissos)
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Quaternari
Neogen
Paleogen (Eocè superior - Oligocè)
Paleogen (Paleocè - Eocè)
MESOZOIC
Cretaci
Juràssic
Triàsic
PALEOZOIC
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Silurià - Devonià - Carbonífer inferior i mitjà
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