Rivista Italiana di Paleontologia e Stratigrafia	volume 111	no. 2	2 pls.	pp. 305-316	July 2005

UPPER KIMMERIDGIAN AND TITHONIAN AMMONITES FROM THE TUNISIAN «DORSALE» (NE TUNISIA): UPDATED BIOSTRATIGRAPHY FROM THE JEBEL OUST

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Received: April 22, 2004; accepted: November 18, 2004

Key words: Upper Kimmeridgian, Tithonian, Ammonites, Calpionellids, Biostratigraphy, Jebel Oust, NE Tunisia.

Abstract. In the context of updating biostratigraphic analysis in the Upper Kimmeridgian-lowermost Berriasian from the whole of the Tunisian Dorsale (NE Tunisia), new results obtained from the Jebel Oust reference section are presented. The bed-by-bed-sampling of a rather rich ammonite fauna gathered in the two most favourable profiles in the area allowed to propose, for the first time, a biozonation for Upper Kimmeridgian to Tithonian limestones. Calpionellids relayed or completed ammonite assemblages, and were also useful for biostratigraphy in beds close to the Jurassic-Cretaceous boundary. The composition of ammonite assemblages, as well as the known ranges for genera and species, is in accordance with the available information from epioceanic areas in West-Mediterranean Tethys. The recognized biozones fit the standard proposal given by Groupe Français D'Etude du Jurassique in 1997. Age-interpretation for turbiditic horizons in the Jebel Oust is made for the first time. In spite of some limitations, the biostratigraphic results obtained in Jebel Oust sections provide a valuable tool for potential correlations with poorly known sections in northern Tunisia, as well as with other Tethyan areas.

Riassunto. Sono presentati in questo lavoro i nuovi risultati sulla biostratigrafia dell'intervallo Kimmeridgiano superiore – Berriasiano basale della Dorsale Tunisina (Nord-Est della Tunisia), ricavati dalla sezione di riferimento del Jebel Oust. Il campionamento strato per strato della relativamente ricca fauna ad ammoniti raccolta nelle due sezioni più favorevoli dell'area in esame ci ha permesso di proporre, per la prima volta, una biozonazione dei calcari del Kimmeridgiano superiore-Titoniano. Le calpionelle si sono rivelate biostratigraficamente utili sia nel sostituire e/o completare le informazioni ottenute in base alle ammoniti, sia per gli strati a cavallo del limite Giurassico-Cretaceo. La composizione delle associazioni ad ammoniti e le distribuzioni verticali conosciute per i generi e le specie sono in accordo con le informazioni disponibili per le aree epioceaniche della Tetide Mediterranea occidentale. Le biozone riconosciute confermano gli standard proposti nel 1997 dal Gruppo Francese di Stratigrafia del Giurassico. L'interpretazione dell'età degli orizzonti torbiditici del Jebel Oust è qui proposta per la prima volta. Nonostante alcuni limiti derivanti dalle condizioni di affioramento, i risultati biostratigrafici ottenuti nelle sezioni del Jebel Oust offrono un valido strumento di correlazione potenziale sia con sezioni scarsamente conosciute del Nord della Tunisia che con altre aree Tetidee.

Résumé. Dans le cadre d'une mise à jour de l'analyse biostratigraphique du Kimméridgien supérieur-Berriasien basal de la Dorsale tunisienne (NE Tunisie), les résultats nouveaux obtenus dans la coupe de référence du Jebel Oust sont présentés. L'échantillonnage banc par banc d'une riche faune d'ammonites, récoltée dans les deux profils les plus favorables de ce secteur, a permis de proposer, pour la première fois, une biozonation des calcaires du Kimméridgien supérieur et du Tithonien. Les calpionelles, complétant ou relayant les ammonites récoltées, ont servi également à la biostratigraphie des niveaux au voisinage de la limite Jurassique-Crétacé. La composition des associations fauniques, ainsi que l'extension des genres et espèces reconnus, sont en accord avec l'information disponible sur les régions épi-océaniques de la Téthys méditerranéenne. Les biozones distinguées cadrent bien avec l'échelle de référence proposée par le Groupe Français D'Etude du Jurassique (1997). Un âge pour les niveaux turbiditiques de la coupe du Jebel Oust est pour la première fois attribué. Malgré l'insuffisance de certaines données pour une étude plus détaillée, les résultats stratigraphiques obtenus au Jebel Oust fournissent un outil valable pour une corrélation potentielle avec les coupes du Nord tunisien, où la stratigraphie est peu connue, ainsi qu'avec d'autres régions téthysiennes.

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Introduction

In the Tunisian 'Dorsale' (NE Tunisia), uppermost Middle to lower-middle Upper Jurassic sections (Lower Callovian to Lower Kimmeridgian Ammonitico Rosso facies) have been recently investigated for revision of ammonite biostratigraphy (Balusseau & Cariou 1982; Soussi et al. 1999). In the same area, calpionellids have been useful for the interpretation of the Jurassic-Cretaceous boundary (Combémorel et al. 1985). However, data on precise ammonite biostratigraphy from the Upper Kimmeridgian and Tithonian are rare throughout the available bibliography. Early biostratigraphic approaches on this stratigraphic interval need updated reinterpretations based on bed-by-bed sampling aiming to a strict stratigraphic control.

In the present paper, ammonite faunas gathered from the Upper Kimmeridgian and Tithonian of Beni Klab Formation in the Jebel Oust Range of the Tunisian Dorsale are first reported. The new data are significant since the Jebel Oust Range was often considered as a local reference section for all Jurassic formations in the area.

The new collected material is currently stored in the University of Granada (Spain), but will be finally stored in the Faculty of Sciences of Bizerte (Tunis).

Previous works

The first report of an Upper Jurassic ammonite gathered from the Tunisian Dorsale (J. Zaghouan) was made by Kobelt (1885). This specimen was attributed to *Perisphinctes kobelti* by Neumayr (1885) who interpreted it as a Tithonian species.

In his first geological map of the Tunisian littoral, Rolland (1888) admitted the existence of the Tithonian stage in the J. Oust, after a document transmitted by the Italian Geological Survey. This stage and/or its subdivisions were also recognized in other areas of the Tunisian Dorsale by Blanckenhorm (1888).

The first approaches to Upper Jurassic stratigraphy established lithological units and stage interpretations made by pioneer authors (Aubert 1892; Baltzer 1893; Canavari 1893; Pervinquière 1903, 1907; De Stefani 1907; Gentil 1924).

The first Upper Jurassic ammonite biozonation in the Tunisian Dorsale was presented by Solignac (1927, p. 65) who identified six zones which he interpreted to range from the Lusitanian (= Argovian plus Rauracian; i.e. Oxfordian), Kimmeridgian to the Tithonian: *Peltoceras transversarium*, *Peltoceras bicristatum* and *Aulacostephanus pseudomutabilis* zones for the Argovian, Rauracian and Kimmeridgian, respectively, and *Oppelia lithographica*, *Perisphinctes contiguus* and *Berriasella privasensis* zones for the Tithonian. Later, Castany (1951, 1955) recognized six stages and substages in the Upper Jurassic of the same area: Callovo-Divesian, Argovian, Sequanian, Kimmeridgian and Lower and Upper Tithonian-Portlandian. Six more detailed paleontological zones were reported: *Macrocephalites macrocephalus* and *Quenstedtceras cordatum* zone for the Callovo-Divesian; *Peltoceras transversarium* zone for the Argovian; *Ochetoceras marantianum* and *Epipeltoceras bicristatum* zone for the Sequanian; *Streblites tenuilobatus* and *Str. achilles* zone for the Kimmeridgian; *Streblites lithographicus*, *Berriasella richteri*, *Perisphinctes contiguus* and *Per. geron* zone for the lower Tithonian-Portlandian; and *Virgatosphinctes transitorius*, *Perisphinctes senex*, *Spiticeras groteanum*, *Dalmasiceras progenitor* and *Berriasella chaperi* zone for the Upper Tithonian-Portlandian. To each of the reported zones, the same author assigned the six corresponding lithofacies: marly limestones alternating with green marly levels; very fossiliferous, red, nodular limestones and schists; yellow and grey some-metre-thick limestones with green marls; nodular limestones; limestone packages with thin marly levels; and sublithographic limestone with marls.

Bonnefous (1972), in his stratigraphic and micropaleontological study of Tunisian Jurassic, presented a

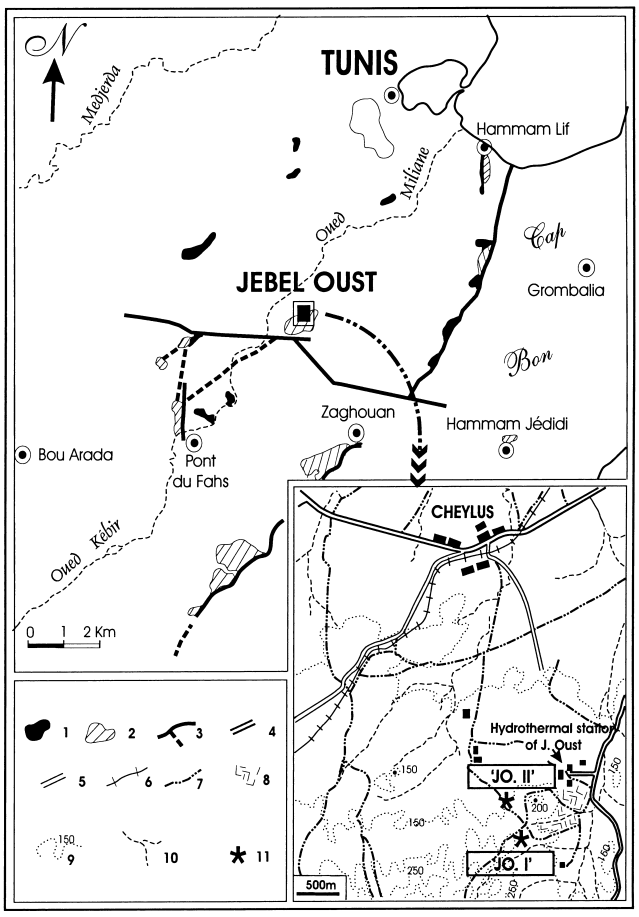


Fig. 1 - The Jebel Oust of the Tunisian Dorsale: location of the studied sections. Triassic (1), Jurassic outcrops (2), fault (3), managed road (4), track (5), railway (6), foot-path (7), roman ruins (8), topographic curve (9), river, ravine (10), and location of the studied sections (11).

well documented monography in which he detailed stratigraphic subdivisions using macro- and microfossils. For ammonites he referred to the recommendations of the International Colloquium of Luxembourg, 1962.

Colom et al. (1953), Bimuth et al. (1967), Busnardo & Memmi (1972), Memmi & Maamouri (1974), Thibieroz (1974), Donze et al. (1975) and Memmi & Salaj (1975) made more thematic contributions on microfacies, calpionellids, foraminifera and cephalopods.

The last two decades have been especially marked by three important papers dealing with Upper Jurassic Stratigraphy in the Tunisian Dorsale. Combémorel et al. (1985) used calpionellids to improve stratigraphy in sedimentary successions close to the Jurassic-Cretaceous boundary. Balusseau & Cariou (1982) investigated ammonite biostratigraphy in Ammonitico Rosso facies at J. Zaress. A recent paper by Soussi et al. (1999) enlarged the same topic to other sections in the Tunisian Dorsale. Throughout the available bibliography, no recent work has dealt with the Upper Kimmeridgian-Lower Tithonian ammonite biozonation in the same area.

Stratigraphy of the Upper Kimmeridgian-Tithonian in J. Oust

Location of the studied sections

Located 25 Km south-westwards from Zaghouan, the J. Oust appears as a dome which is 396 m high. The Jurassic series crops-out in the middle part of an E-W large and complex anticline with faulted and refolded flanks showing Cretaceous and Tertiary outcrops. Lower Jurassic beds show unconformable contact with overlying Bathonian-Lower Oxfordian rocks. The Kimmeridgian and Tithonian strata crops-out in a large band occupying the northern side of J. Oust and are organized in 30-40°N dipping strata. The studied sections are located in the northeastern flank of the range (Fig. 1): Section JO.I from A 36°.31.77N, 010°.03.76E to B 36°.31.88N, 010°.03.83E; and Section JO.II: from A' 36°.32.02N, 010°.03.64E to B' 36°.32.04N, 010°.03.60E. In the latter section, complementary GPS coordinates for the end of subsections A, B, and C are 36°.32.02N, 010.03.04E; 36°.32.04N, 010°.03.65E; and 36°.32.03N, 010°.03.65E, respectively.

Lithological succession and faunas

The section 'JO.I'. A total 55 m-thick section has been analysed, but only the upper fossiliferous half of the section is represented in Fig. 2. Small faults and occasional soil-covering only have minor incidence for precise stratigraphy. The section is mainly made of light-brown to grey limestone with intercalated marls; the thickness of the latter varies between some centimetres and two metres. Bedding is well developed in limestone packages, which most frequently show beds 10-15 cm and less than 10 cm thick (29 and 20 beds, respectively). In addition, a decreasing order of frequency shows bed thickness of 20 cm (16 cases), of 22-25 cm and 40 cm in 8 cases, and of 30-35 cm in 6 cases. At the base of the section studied, a single bed was found to be 60-65 cm thick. Commonly, bed tops show variable ferruginisation and irregular to undulated surface. Pinch-out of beds has been observed in limestone horizons within marly intervals. Occasionally, reddish coloration occurs in marly intercalations, but it is more typical in more or less nodular marly limestones, which are relatively fossiliferous, and then in ammonitico rosso-like facies that exist upwards in the section.

Throughout the studied section, the majority of ammonite remains are preserved as inner-mould fragments, together with complementary material made of bivalves and some belemnites. Aptychi, mainly *Lamellaptychus*, are occasionally frequent in some horizons. Ammonite preservation is poor for precise description of morphologic features, but good enough for the identification at the genus level, even at the species level in some cases.

At the base of the section (beds 13-25; Fig. 2, JO.I; Pl.1), the oldest ammonite assemblages gathered are composed of *Orthosphinctes* sp. (F1), *Metahaploceras* sp. (F2); *Metahaploceras* sp., *Sowerbyceras* sp. (F3); *Presimoceras* sp. or *Mesosimoceras* sp. gr. *cavouri* (Gemmellaro)-*risgoviensis* (Schneid) (F4). No ammonite remains have been found in the middle part of the section (beds 26-53); however, higher beds in the section (beds 54-77) are more frequently fossiliferous. The following ammonites were collected: *Sowerbyceras* sp., cf. *Torquatisphinctes* (juvenile specimen) (F5); *Hybonoticeras verestoicum* (Herbich), *Biplisphinctes cimbricus* (Neumayr), *Trapanesites* sp. gr. *adelus* (Gemmellaro), *Discosphinctoides* sp., *Taramelliceras pugile pugiloides* (Canavari) (F6). In the reddish ammonitico rosso-like facies (beds 61-69) the ammonite assemblages F7 and F8 are composed, respectively, of *Taramelliceras* sp. gr. *compsum* (Oppel) and *Schaireria pipini* (Oppel), *Virgalithacoceras* sp. gr. *riedense-eystettense* (Schneid). Overlying a soil-covered interval, the first fossiliferous beds (66, 68, 69 and 77) delivered ammonite assemblages F9 (*Haploceras* sp. gr. *elimatum* (Oppel)), F10 (*Fontanniella* sp., *Haploceras elimatum* (Oppel), *Hybonoticeras hybonotum* (Oppel), "*Subdichotomoceras*" *pseudocolubrinum* (Kilian), *Haploceras carachtheis* (Zeuschner)), F11 (*Haploceras* sp. cf. *verruciferum* (Meneghini), *Ptycophylloceras* sp., *Haploceras carachtheis* (Zeuschner), *Substreblites* sp.), and F12 (*Pseudokatroliceras* sp. and poorly preserved Streblitinae).

The first grey nodular beds (corresponding to debris flows deposits) yielded ammonite assemblages F13 (bed 81) and F14 (bed 84). These ammonite assem-

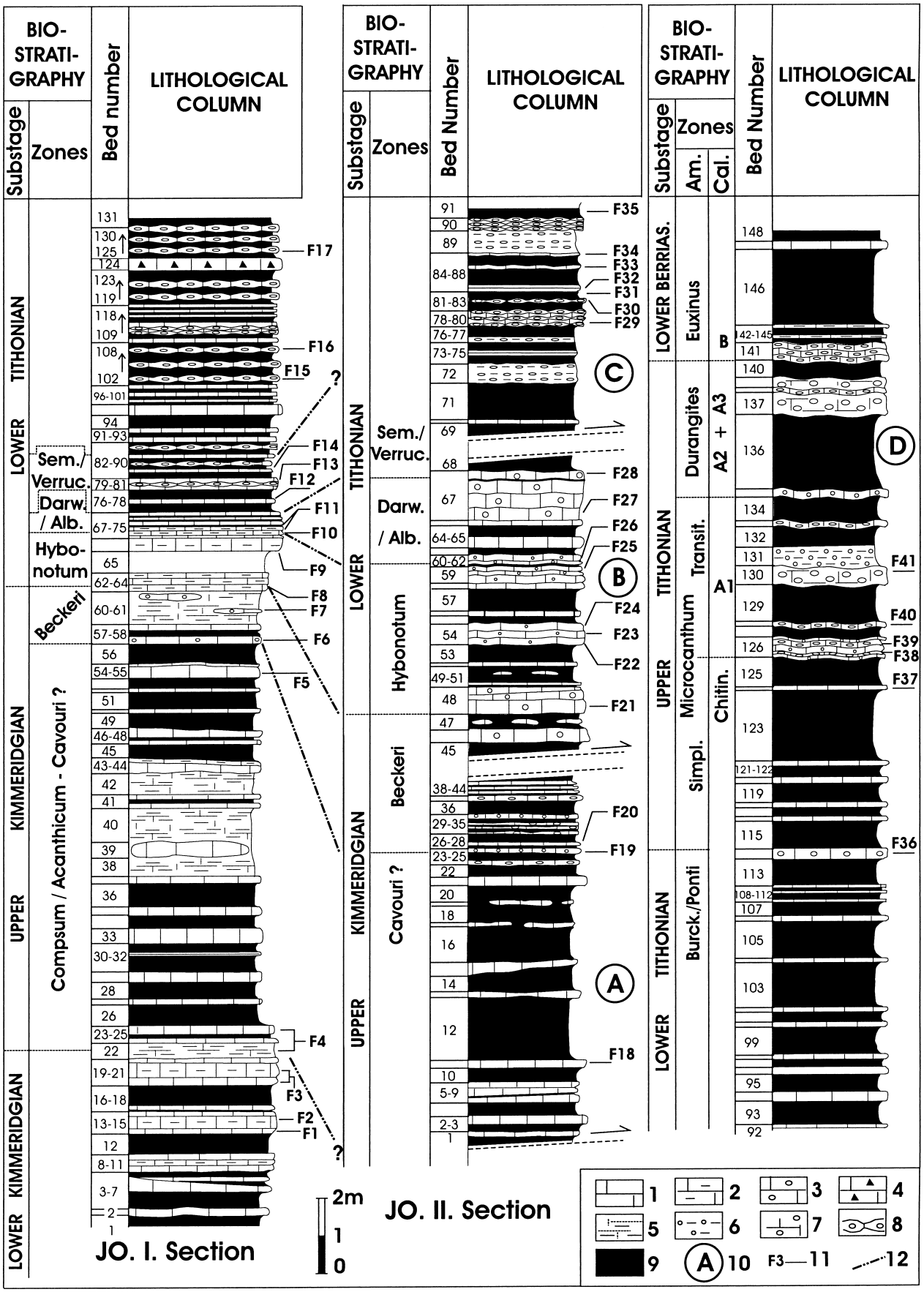


Fig. 2 - Lithological succession of the studied sections, fauna and biostratigraphic interpretation. Limestone (1), marly limestone (2), nodular limestone (3), cherty limestone (4), calcareous marls (5), nodular bed with marly matrix and irregular bedding surfaces (6), nodular bed with calcareous matrix and irregular bedding surfaces (7), Breccia (8), marly level (9), sub-section (10), ammonite assemblages (11), and correlation (12).

blages are composed of *Simocosmoceras* sp., *Pseudolissoceras* sp., *Semiformiceras* sp., *Haploceras carachtheis* (Zeuschner) (F13) and *Pseudodiscosphinctes* sp. (F14).

In the highest beds of the section (beds 103, 107 and 126) were gathered ammonite assemblages F15 (*Haploceras* sp. and *Ptychophylloceras* sp.), F16 (*Haploceras elimatum* (Oppel) and some related forms, *Ptychophylloceras* sp.) and F17 (*Ptychophylloceras* sp., "*Subdichotomoceras*" *pseudocolubrinum* (Kilian), *Lemencia* sp. and/or *Parapallasiceras* sp, cf. *Burckhardticeras*, and a single, loose specimen of *Semiformiceras* sp).

The section 'JO. II'. Bed succession is disturbed by intense faulting. Careful analysis of the lateral continuity of some reference levels and the systematic checking of ammonite biostratigraphy have permitted to connect the four profile sub-sections A, B, C and D (Fig. 2), which made the composite section presented in stratigraphic order on Fig. 2. In fact, the apparent order in which these sub-sections superimpose on the field is B, A, C, D, without any notable change in dipping of beds. Faults parallel to bedding, passing throughout marly levels, limit the two first sub-sections A and B that are considered to be thrust slides. The faulting trace is only marked by a thin tectonic microbreccia separating marly levels 1 and 68 (Fig. 2; JO. II, A & B).

The 10 m-thick sub-section A consists of light grey limestones alternating with yellowish marls. Reddish coloration at the base of the section occurs. The thickness of marly levels varies between some centimetres and 1.70 m. Limestone packages exhibit upward decreasing thickness and frequently show beds 10-15 cm and less than 10 cm thick. A decreasing order of frequency shows bed thickness of less than 10 cm in 9 cases, of 10-15 cm in 8 cases, and of 20-35 cm in 5 cases.

In the lower part of this section, the bed 11 gave *Taramelliceras* sp. and *Lingulaticeras* sp. (ammonite assemblage F18). In the two adjacent limestone beds 25 and 27 we gathered, respectively: *Hybonoticeras* sp., cf. *Torquatisphinctes*, cf. *Biplisphinctes*, a dense ribbed *Lithacoceratinae*, *Lingulaticeras* sp., *Sowerbyceras* sp., *Holcophylloceras* sp., *Lytoceras polycyclum* (Neumayr) (ammonite assemblage F19), and *Hybonoticeras beckeri* (Neumayr), *Hybonoticeras* sp. gr. *harpephorum* (Neumayr), *Hyb. harpephorum crassicostatum* Olóriz, *Subplanites* sp. *Virgataxioceras* sp. aff. *setatulum* Berckhemer & Hölder, *Hemihaploceras* sp. aff. *nobile* (Neumayr) *Sowerbyceras* sp., *Holcophylloceras* sp. gr. *silesiacum* (Oppel), *Holc.* sp. and *Callyphylloceras* sp. (ammonite assemblage F20) (Pl. 2).

The sub-section B is 8 m thick; it is made of light grey, yellow and reddish, somewhat nodular limestones with irregular surfaces, which alternate with white-to-cream marly levels. Limestone beds are well developed showing thickness from 5 cm to 1.50 m, and frequently beds 20-60 cm thick. Ammonite faunas were gathered from several fossiliferous horizons. In the lower part of the sub-section, bed 48 yielded *Hybonoticeras* sp. gr. *hybonotum* (Oppel), *Hyb*. sp. gr. *trapeciale* Olóriz, *Torquatisphinctes* sp., *Schaireria* sp., *Holcophylloceras* sp. and a dense ribbed fragment of Lithacoceratinae (ammonite assemblage F21). The lower, middle and upper horizons of fossiliferous bed 54 gave, respectively, *Torquatisphinctes* sp., *Aspidoceras rogoznicense* (Zeuschner), *Asp*. sp. gr. *longispinum* (Sowerby), *Haploceras* sp., *Neochetoceras* sp., *Holcophylloceras* sp. cf. *silesiacum* (Oppel), *Holc.* sp. gr. *polyolcum* (Benecke), cf. *Sowerbyceras*, *Lytoceras polycyclum* (Neumayr) (ammonite assemblage F22); *Hybonoticeras* sp. gr. *hybonotum* (Oppel), *Hyb. hybonotum autharis*, (Oppel), *Virgalithacoceras* cf. *supremum* (Sutner), *Torquatisphinctes* cf. *laxus* Olóriz, *Schaireria* sp. cf *neumayri* Checa, *Aspidoceras longispinum* (Sowerby), *Haploceras* sp. gr. *elimatum* (Oppel), *Sowerbyceras* sp. and *Holcophylloceras* sp. (ammonite assemblage F23); and *Subplanites* sp. gr. *postruepellianus* (Quensted) – sp. cf. *elegans* (Spath in Valduga) – sp.1 Olóriz, *Schaireria neumayri* Checa, *Aspidoceras* sp., *Haploceras* sp. cf. *charactheis* (Zeuschner), *Hapl.* sp., *Holcophylloceras* sp., *Lytoceras polycyclum* (Neumayr) (ammonite assemblage F24).

Higher in this section, *Hybonoticeras hybonotum* (Oppel), *Hyb*. sp., *Schaireria* sp., *Haploceras* sp. gr. *elimatum* (Oppel), *Hapl.* sp., *Pseudolissoceras rasile* (Oppel), *Ps*. sp. aff. *rasile* (Oppel *in* Olóriz, 1978), *Taramelliceras* sp., *Fontannesiella* sp. cf. *valentina* (Fontannes), *Holcophylloceras* sp., cf. *Ptycophylloceras*, *Lytoceras* sp. gr. *orsinii* Gemmellaro - *liebigi* (Oppel) (ammonite assemblage F25) have been collected; *Virgatosimoceras albertinum* (Catullo), *Virg*. sp. gr. *albertinum* (Catullo), *Haploceras* sp. gr. *elimatum* (Oppel) - *staszycii* (Zeuschner), *Lytoceras polycyclum* (Neumayr) and a dense ribbed fragment of Lithacoceratinae (ammonite assemblage F26); *Semiformiceras darwini* (Neumayr), *Substreblites* sp., *Haploceras* sp., *Lytoceras* sp. gr. *montanum* (Oppel), *Lyt.* sp., *Phylloceras* sp. and fragments of Lithacoceratinae (ammonite assemblage F27); and *Haploceras* sp. cf. *verruciferum* (Oppel) and *Haploceras carachtheis* (Zeuschner) (ammonite assemblage F28).

The 6.2 m-thick sub-section C is mainly composed of thin, bioturbated, grey nodular limestone (debris flow deposits) with white, marly intercalations. Well stratified, centimetre-thick, limestone beds are intercalated. Poor ammonite fauna was gathered: "*Subdichotomoceras*" *pseudocolubrinum* (Kilian), *Schaireria neoburgensis* (Oppel) (ammonite assemblage F29); *Schaireria neoburgensis* (Oppel), *Haploceras* sp. gr. *carachtheis* (Zeuschner) (ammonite assemblage F30); *Schaireria neoburgensis* (Oppel), *Aspidoceras rogoznicense* (Zeuschner), *Haploceras* sp. gr. *elimatum* (Oppel), *Holcophylloceras* sp., *Callyphylloceras* sp., *Lytoceras* sp. gr. *liebigi* (Oppel), *Protancyloceras guembeli* (Oppel) and

dense ribbed fragments of Lithacoceratinae (ammonite assemblage F31); *Haploceras* sp., *Calliphylloceras* sp., *Phylloceras* sp., *Lytoceras* sp. and fragments of Lithacoceratinae (ammonite assemblage F32); *Calliphylloceras* sp. (ammonite assemblage F33); *Phylloceras* sp. and fragments of Lithacoceratinae (ammonite assemblage F34); and «*Subdichotomoceras*» sp. cf. *pseudocolubrinum modicun* Olóriz (ammonite assemblage F35).

Analysed beds of sub-section D relay those of sub-section C without any disturbing faults. This section can be divided into two lithological units. The lower one (beds 92-125; Fig. 2, 'JO.II' D) consists of white to light grey marly levels with intercalated thin limestone beds. The thickness of the latter varies between 5 cm and 30 cm, but most frequently they are less than 10 cm thick. A decreasing order of frequency shows bed thickness of less than 10 cm in 13 cases, of 13-25 cm in 5 cases, and only one bed exceeds 30 cm in thickness. On the other hand, marly levels show thickness variation between some centimetres (1 case) and more than 1 m (a single case), but more frequently they are 20-50 cm thick (eight cases) or 60 cm-1 m thick (six cases). Throughout this lithological unit, were gathered *Burckhardticeras* sp. (macroconchiate specimen), *Zittelia* sp. cf. *eudichotoma* (Zittel) or *Andalusphinctes* sp. gr. *sapunovi* Tavera in bed 114 (ammonite assemblage F36) and only *Phylloceras* sp. (ammonite assemblage F37) in bed 124. In another close sub-section, the same bed 114 gave *Burckhardticeras* sp. cf. *peroni* (Roman), "*Subdichotomoceras*" sp. cf. *pseudocolubrinum* (Kilian), a fragment of cf. *Lemencia*, *Haploceras* sp. gr. *staszycii* (Zeuchner), *Haploceras* sp. gr. *carachtheis* (Zeuschner), *Ptychophylloceras* sp. and *Phylloceras* sp. (included in ammonite assemblage F36).

Compared to the lower lithological unit analysed above, the upper one (beds 126-146) is mainly characterized by grey nodular limestones with irregular surfaces, intercalated in relatively thick marly horizons. These debris flow deposits can be compared easily to those of the sub-section C; however, nodular limestone beds are slightly thicker and some of them show lithoclasts floated in a marlier matrix. Marly horizons of both the lower and upper lithological units are of nearly the same thickness. Through the lower part of the upper unit were collected: *Micracanthoceras microcanthum* (Oppel) cf. morphotype *C* Tavera, *Aulacosphinctes* sp. gr. *sulcatus* Tavera, *Aulacosph*. sp. and loose specimens of *Aulacosphinctes* sp., and a juvenile specimen of *Tithopeltoceras* n. sp. gr. *arkelli-haranense* Olóriz & Tavera (ammonite assemblage F38); *Micracanthoceras* sp. gr. *microcanthum* (Oppel), *Micrac*. sp. juv. cf. *brightoni* (Spath), *Micrac*. n. sp. A, *Aulacosphinctes* sp. gr. *sulcatus* Tavera, *Aulacosph*. sp., *Paraulacosphinctes transitorius* (Oppel), *Paraulac*. sp. cf. *transitorius* (Oppel), *Paraulac*. sp., *Moravisphinctes latus* Tavera, cf. *Oloriziceras* sp. gr. *salarense-checai* Tavera, *Tithopeltoceras* n. sp. gr. *arkelli-haranense* Olóriz & Tavera, *Haploceras* sp. cf. *elimatum* (Oppel), *Hapl*. sp. gr. *carachtheis* (Zeuschner), *Holcophylloceras* sp., *Lytoceras* sp. (ammonite assemblage F39); *Aspidoceras* sp. (? macroconchiate specimen gr. *rafaeli* Oppel), *Asp*. sp., *Schaireria* sp. cf. *neoburgensis* (Oppel), *Haploceras* sp. gr. *charachtheis* (Zeuschner), *Calliphylloceras* sp. (ammonite assemblage F40); and *Micracanthoceras microcanthum* (Oppel) cf. morphotype *E* Tavera or *Corongoceras* sp., *Moravisphinctes* sp. gr. *latus* Tavera, *Morav*. sp. gr. *fischeri* (Kilian) - *moravicus* (Oppel), *Paraulacosphinctes* sp. gr. *senex* (Oppel) – *senoides* Tavera, *Haploceras* sp. gr. *staszycii* (Zeuschner), *Hapl*. sp. gr. *charachtheis* (Zeuschner), *Ptycophylloceras* sp., *Holcophylloceras* sp., *Phylloceras* sp., *Lytoceras* sp. and loose specimens of *Moravisphinctes* sp. gr. *fisheri* (Kilian)-*moravicus* (Oppel) (ammonite assemblage F41).

Biostratigraphy

Bio-chronostratigraphic standards for reference and interpretation of ammonite data are those proposed by the Groupe Français d'Etude du Jurassique (1997), which are complemented with precise data included in Olóriz (1978), Sarti (1993), and Caracuel et al. (1998). For calpionellids, we used the standard proposed by Remane et al. (1986); the biozonations established by Enay & Geyssant (1975) and by Cecca et al. (1989) were also useful for correlation of ammonite and calpionellid assemblages.

Biostratigraphic interpretation of the Section 'J.O. I'. The range obtained for *Metahaploceras*, which embraces the records of *Orthosphinctes* and *Presimoceras* or *Mesosimoceras* indicates upper Lower to Upper, but not uppermost, Kimmeridgian for horizons containing ammonite assemblages F1 to F4. Upwards in the section, ammonite assemblage F5 provided a single juvenile specimen of probable *Torquatisphinctes*, close to the first appearance of ammonitico rosso-like facies with *Hybonoticeras*, which agrees with the Upper Kimmeridgian, most possibly the upper part of the Cavouri Zone. The first appearance datum (FAD) for the genus *Hybonoticeras*, which is represented by *H. verestoicum* (Herbich) indicates the lower part of the Beckeri Zone. The finding of associated *Biplisphinctes cimbricus* (Neumayr), *Trapanesites* sp. gr. *adelus* (Gemmellaro) and *Taramelliceras pugile pugiloides* (Canavari) reinforces this interpretation. A conclusive interpretation can not be made for beds bearing ammonite assemblages F7-F8 since they contained ammonites that are found in both the uppermost Kimmeridgian and the lowermost Tithonian.

The FAD of the genus *Haploceras* is used for the effective recognition of the Tithonian in Tethyan areas, i.e. Mediterranean province or epioceanic Tethys, although it is known from the uppermost Kimmerid-

gian in southern France (e.g. Hantzpergue et al. 1997). A 60 cm thick, covered interval precedes the FAD of *Haploceras* recorded in ammonite assemblage F9. The overlying horizons contain ammonite assemblage F10 in which *Fontannesiella* and *Hybonoticeras hybonotum* (Oppel) are registered. All these data are in accordance with the Lower Tithonian Hybonotum Zone, the lower part of which could be under the mentioned soil covering. The crowded fossiliferous assemblages F11 and F12 could belong to the Albertinum/Darwini Zone or to the lowermost Semiforme/Verruciferum Zone. The ammonite assemblage F13 belongs to the Semiforme/Verruciferum Zone on the basis of the combined record of *Simocosmoceras*, *Semiformiceras* and *Pseudolissoceras*.

Upsection, ammonite assemblages are not significant for precise biostratigraphy at the zone level, but the record of *Lemencia*, and/or *Parapallasiceras*, indicates the upper Lower Tithonian below the typical epibole of simoceratins, which, on the whole, most probably relates to their acme in the epioceanic Tethys.

Biostratigraphic interpretation of the Section 'J.O. II'. At the base of the section (subsection A), the ammonite assemblage F18 is represented by *Taramelliceras* and *Lingulaticeras* that have a relative large range (Upper Kimmeridgian-Lower Tithonian). Higher in the section, among species of the close ammonite assemblages F19 and F20, was recorded *Hybonoticeras beckeri*, the index species of the uppermost Kimmeridgian Beckeri Zone. Associated *Subplanites* and *Biplisphinctes* may indicate the lower part of this zone. Throughout the subsection B, ammonite assemblages F21, F23 and F25 include the index species *Hybonoticeras hybonotum* marking the lowermost Tithonian Hybonotum Zone. *Virgatosimoceras albertinum* in ammonite assemblage F26 and *Semiformiceras darwini* in ammonite assemblage F27 are both used as index species for the Albertinum/Darwini Zone. *Haploceras verruciferum* belongs to ammonite assemblage F28 that indicates the Semiforme/Verruciferum Zone. From these data we can conclude that the uppermost Kimmeridgian Beckeri Zone corresponds here to the sedimentary package that includes beds from 25 at the base (FAD of *Hybonoticeras beckeri*) to 47 (bed 48 records the FAD of *Hybonoticeras hybonotum*). Lower beds belong to the Upper Kimmeridgian; the identification of biostratigraphic subdivisions at the subzone level is not possible. The top of the Hybonotum Zone is located below the base of bed 61 that yielded ammonite assemblage F26, which belongs to the overlying Albertinum Zone. Only the top of bed 67, containing ammonite assemblage F28, is included in the lower part of the Verruciferum Zone. Higher in the section, ammonite assemblages F29 to F35 indicate undifferentiated upper Lower Tithonian.

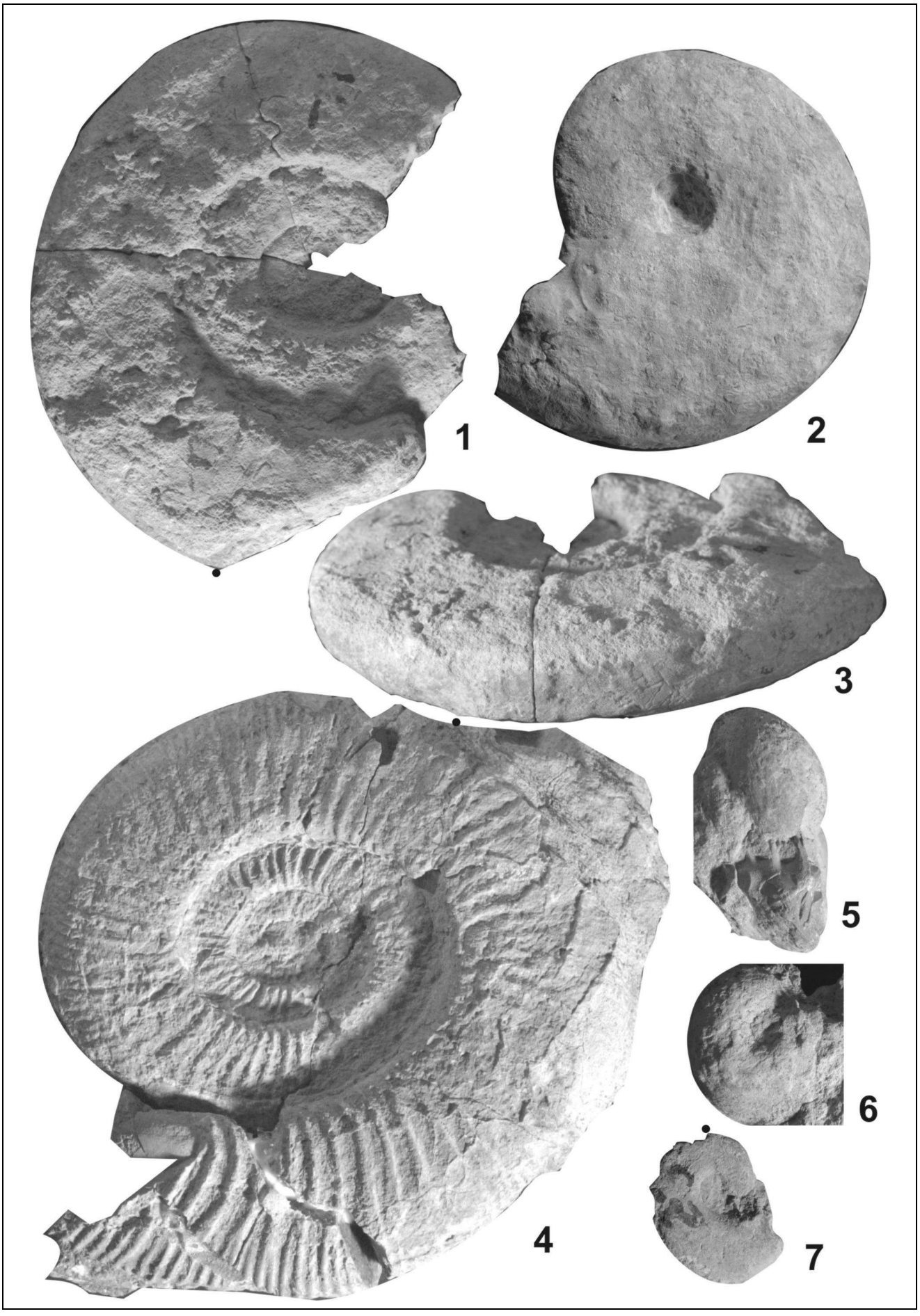
In the lower part of the subsection D (beds 92-113), no ammonites have been collected. Horizons close to the Lower-Upper Tithonian boundary are indicated by ammonite assemblage F36 gathered from the single, condensed bed 114 that includes *Zittelia* of the Microcanthum Zone together with *Burckhardticeras* of the Burckhardticeras/Ponti Zone. The first, strictly Upper Tithonian ammonite assemblages were found in ammonite assemblages F38, F39 and F41, in which we recorded the significant ammonite species *Micracanthoceras microcanthum* and *Paraulacosphinctes transitorius*. The former is the index species of Upper Tithonian Microcanthum Zone, and the latter is that of its upper Transitorius Zone or Subzone according to authors. Associated ammonites such as *Moravisphinctes moravicus*, *Morav. fischeri*, *Paraulacosphinctes* gr. *senex*, *Oloriziceras*, and *Tithopeltoceras* are all typical faunas of the stratigraphic interval mentioned.

This interpretation is reinforced and complemented by calpionellid data. In fact, the genus *Chitinoidella* Bonet is recorded from bed 124 with only three specimens included in *Chit.* gr. *boneti* (Doben). The first appearence of calpionellids is recorded in the middle part of bed 126 with small variety of *Tintinnopsella carpathica* (Murg. & Filip.) and of *Crassicollaria* aff. *intermedia* (Durand-Delga). The same assemblage characterizes the calpionellid faunas recorded from beds 128, 130 and 133 showing the upward decrease in *Tintinnopsella carpathica*. The first occurrence of a large variety of *Calpionella alpina* Lorenz associated to few specimens of *Cr. massutiniana* (Colom) are recorded in bed 135 at the base of which we place the boundary between A1 and A2 (=Remanei/Intermedia) calpionellid Subzones.

In bed 138 are associated *Calpionella alpina* (22%), *Crassicollaria brevis* Remane (6%), *Cr. parvula* Remane (25%), *Cr. massutiniana* (21%) and *Tintinnopsella carpathica* (26%). This assemblage indicates the upper part of A3 (=Upper Intermedia) Subzone. The

PLATE 1

Fig. 1, 3 - *Hybonoticeras verestoicum* (Herbich), entirely chambered?, F6, J.O.I section, bed 57, Upper Kimmeridgian, lower Beckeri Zone. Fig. 2 - *Taramelliceras* sp. gr. *compsum* (Oppel), phragmocone, F7, J.O.I section, bed 61, Upper Kimmeridgian, Beckeri Zone. Fig. 4 - *Trapanesites* sp. gr. *adelus* (Gemmellaro), slightly less than the half outer-whorl is body chamber, F6, J.O.I section, bed 57, Upper Kimmeridgian, lower Beckeri Zone. Fig. 5-6 - *Schaireria neoburgensis* (Oppel), entirely chambered?, F29, J.O.II section, sub-section C, bed 79, undifferentiated Lower Tithonian (Semiforme/Verruciferum Zone?). Fig. 7. *Haploceras carachtheis* (Zeuschner), slightly more than the half outer-whorl is body chamber, F10, J.O.I section, bed 68, lowermost Tithonian, upper Hybonotum Zone. Dots for location of the outermost suture line identified. All specimens at natural size.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explosion of small variety of *Calpionella alpina* (58%) associated to *Crassicollaria parvula* (34%) and *Tintinnopsella carpathica* (8%) is noted in bed 141, at the base of which we place the Upper Tithonian-Lower Berriasian boundary. Upwards, slight difference in these species proportions is seen in beds 142 and 145. All these levels mark the lowermost B zone of calpionellids (=Alpina Subzone of the Calpionella Zone).

Correlation. Although the studied sections crops-out in a small area in J. Oust, the correlation of their lithological units shows a clear change in facies, close to the Kimmeridgian-Tithonian boundary (Fig. 2). Throughout the Beckeri zone, the ammonitico rosso-like facies of the section 'JO.I' pass to the north-west (section 'JO.II') into more regular thin-bedded sedimentary packages of limestone beds with intercalation of marly levels of nearly the same thickness. Upwards, condensed horizons, composed of thin grey limestone beds and intercalated white marly levels, of Hybonotum and Albertinum/Darwini Zones in 'JO.I' correspond to thicker deposits of yellow and reddish, somewhat nodular, limestones with irregular surfaces which alternate with white to cream marly levels in 'JO.II'. Close to the Kimmeridgian-Tithonian boundary, in this area, tectonic control of deposition seems to be of major influence: the Kimmeridgian basement in J. Oust could have experienced reactivation of extensional faulting that controlled facies distribution and thickness. This event is interpreted to be related to a distensive regime locally forced by Tethyan Rifting.

Debris flow deposits at J. Oust: age and depositional environment

Throughout the studied sections, the vertical distribution of facies in the Upper Kimmeridgian-Tithonian of Beni Klab formation shows two episodes of resedimented carbonates. These deposits are henceforth considered to be of Early and Late Tithonian age, respectively (Verruciferum-Fallauxi Chrons? and late Microcanthum-Durangites Chrons). Such deposits mark two important changes in facies, certainly related to tectonic and/or eustatic controlling events. They are placed relatively close to the lower and the upper boundaries of the Tithonian stage and correspond to discontinuities also widely reported from other peri-Mediterranean ranges of western Tethys (Atrops et al. 1991 and Atrops & Benest 1993 for Algeria; Marques et al. 1991 for South Iberia; and Benzaggagh 2000 for Morocco; among others).

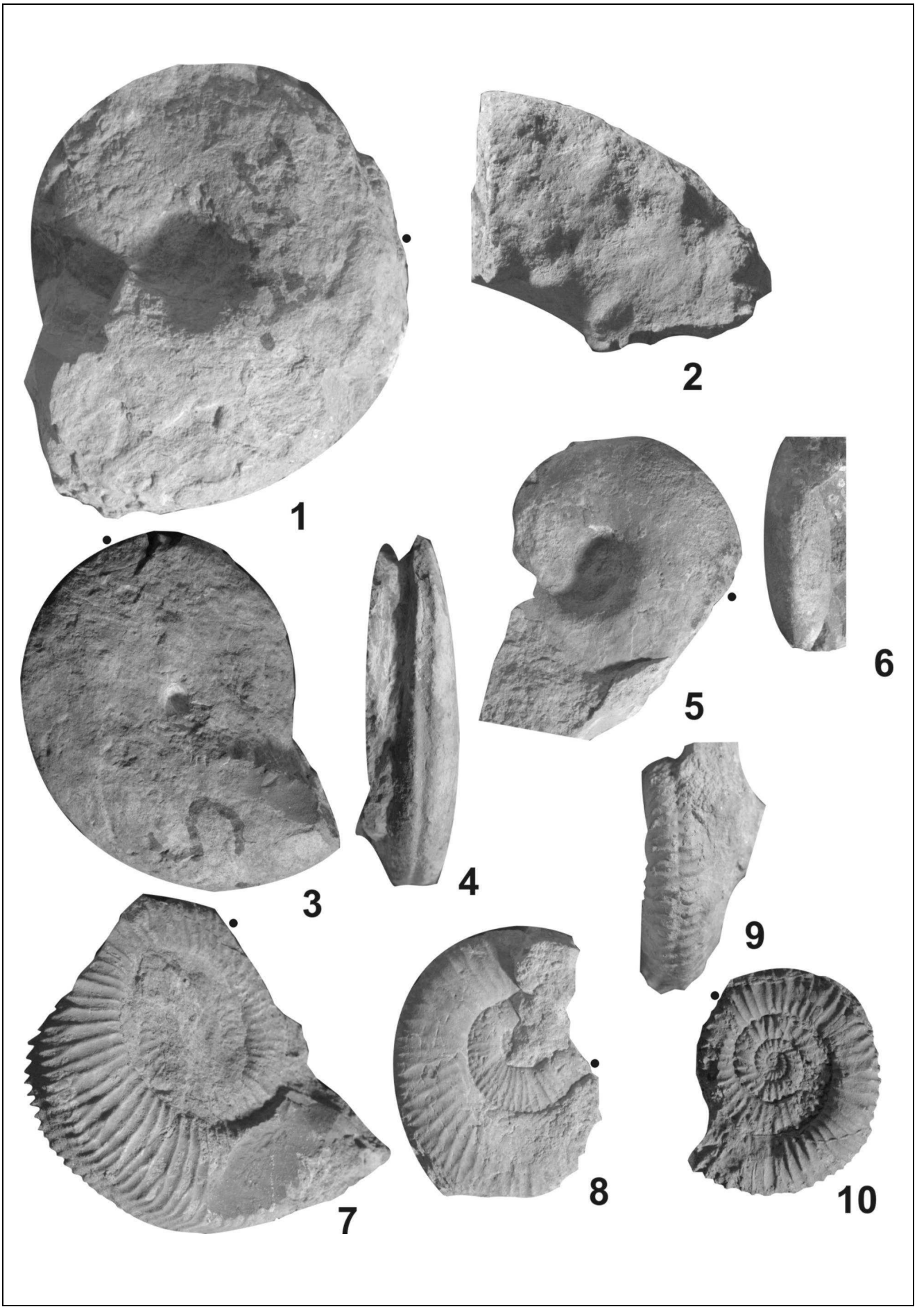
These facies of debris flow deposits show a clear difference, showing the lower unit a clast-supported fabric, while the upper one is matrix-supported. Their lateral equivalents seem to be the calcareous turbidites reported to the north-west, in the J. Ammar section by Peybernes et al. (1994). Preliminarily, we consider that both these deposits correspond to gravity-flow derived sediments, and that they are spatially related: proximal gravellous facies in Jebel Oust, deposited from high-density flows, passing into more distal turbidites (Bouma' sequences included) in J. Ammar, which were deposited further down-flow by low-density turbidity currents. Thus, we assume that the difference in lithologic features is only due to a change in the character of the turbidity currents (Tucker in Tucker & Wright 1992).

Conclusions

In the present paper, are reported for the first time ammonite assemblages sampled bed-by-bed in the Upper Kimmeridgian and Tithonian of Beni Klab formation in the Jebel Oust Range of the Tunisian Dorsale. Although ammonite preservation is moderate, it is good enough for biostratigraphy. The compositions of ammonite assemblages, as well as the known ranges for genera and species, are in accordance with the available information from epioceanic areas in West-Mediterranean Tethys. The recognized biozones fit the standard proposal given by G.F.E.J in 1997. The lateral equivalents of the studied units were found westwards in North Africa, in the southern edge of Tell range in Algeria (Atrops & Benest 1984, 1986, 1993; Atrops et al. 1991).

PLATE 2

Haploceras elimatum (Oppel), outer quarter is body chamber, F10, J.O.I section, bed 70, lowermost Tithonian, upper Hybonotum Zone. Fig. 2 - *Hybonoticeras* sp. gr. *hybonotum* (Oppel), body chamber fragment, F21, J.O.II section, sub-section B, bed 48, lowermost Tithonian, lower Hybonotum Zone. Fig. 3-4 - *Semiformiceras darwini* (Oppel), slightly more than the half outer-whorl is body chamber, F27, J.O.II section, sub-section B, bed 67a (lower part), Lower Tithonian, Albertinum/Darwini Zone. Fig. 5-6 - *Pseudolissoceras rasile* (Oppel), outer quarter is body chamber, F25, J.O.II section, sub-section B, bed 59c (upper part), lowermost Tithonian, uppermost Hybonotum Zone. Fig. 7 - *Aulacosphinctes* sp. gr. *sulcatus* Tavera, body chamber exceeding the outer half-whorl (c. three-quarters of the last whorl), F39, J.O.II section, sub-section D, bed 126c (upper part), Upper Tithonian, lowermost Transitorius Zone (or Subzone). Fig. 8 - *Moravisphinctes* sp. gr. *fischeri* (Kilian) - *moravicus* (Oppel), last whorl preserved is body chamber, F41, J.O.II section, sub-section D, bed 130c (upper part), Upper Tithonian, lower-to-middle Transitorius Zone (or Subzone). Fig. 9-10 - *Micracanthoceras* sp. gr. *microcanthum* (Oppel) close to morphotype *C* Tavera, two-thirds of the outer whorl is body chamber, F39, J.O.II section, sub-section D, bed 126, Upper Tithonian, lowermost Transitorius Zone (or Subzone). Dots for location of the outermost suture line identified. All specimens at natural size.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Compared to contemporaneous units in Tunisia (North-South Axis and neighbouring areas), and to those in NW Tunisia, the outer-shelf facies of Jebel Oust can be easily integrated in a geodynamic model for the south Tethyan epioceanic margin of Tunisia, which was covered by a north-eastward deepening sea. Furthermore, the combined-section studied is considered to be a reference for the Upper Kimmeridgian and Tithonian of northern Tunisia that provides a basis for integrated biostratigraphy for: 1) the precise local to regional correlation of lithological units in Tunisia; 2) revealing factors controlling facies distribution in the area; and 3) the evaluation of the potential correlation with other Tethyan areas.

Acknowledgements. This research was supported by the collaboration Project G003/2000 between I.C.C.T.I (Portugal) and S.E.R.S.T (Tunisia). Spanish contribution was conducted through BTE2001-3029 Project (MCyT) within the research frame of the EMMI Group (RNM 178 Juna de Andalucia). We acknowledge the suggestions made by F. Cecca (Univ. Pierre et Marie Curie, Paris VI) and C. Sarti (Univ. Bologna) during the revision of the manuscript.

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