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A Condensed Mesozoic Succession North of İzmir: A Fragment of the Anatolide-Tauride Platform in the Bornova Flysch Zone

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Abstract: The Bornova Flysch Zone consists of large blocks of Mesozoic limestone, basalt, serpentinite and radiolarian chert in a highly sheared clastic matrix of latest Cretaceous to Paleocene age. We describe a condensed Mesozoic section from a limestone block near the village of Urbut, 27 km southwest of Bigadiç, north of İzmir. The section, 81 m thick, starts with massive, thickly-bedded Upper Triassic carbonates with megalodonts and foraminifera characteristic of Late Norian–Rhaetian. These are unconformably overlain by condensed, hemipelagic Tithonian–Middle Albian limestones, 19 m thick, with gaps in the succession. The condensed sequence is, in turn, unconformably overlain by red, pink *Rotalipora*- and *Globotruncana*-bearing pelagic limestones of Late Cretaceous age. The Upper Cretaceous section is at least 50 m thick, the basal parts contain foraminifera characteristic of late Cenomanian which pass up into lower–middle Turonian carbonates. The Turonian pelagic limestones contain Valanginian and Upper Triassic limestone clasts, and Tithonian and Upper Triassic carbonate olistoliths, several metres across. The stratigraphy of the Urbut section is similar to that of the Domuzdağ unit in the Lycian nappes and that of the Boyalı Tepe unit in the central Taurides; all are characterized by neritic Upper Triassic carbonates at the base, overlain unconformably by a condensed pelagic limestone sequence of Upper Jurassic–Lower Cretaceous age; pelagic Upper Cretaceous limestones lie unconformably above the Lower Cretaceous or directly on the Upper Triassic/Liassic carbonates. The Urbut section shows several foundering events in the Anatolide-Tauride carbonate platform; the latest one in the late Cenomanian is probably related to the inception of the ophiolite obduction. The Urbut section also provides additional data in favour of the derivation of the Lycian nappes and equivalent allochthonous units from north and northwest of the Menderes Massif.

Key Words: Bornova Flysch Zone, Anatolide-Tauride carbonate platform, Meosozic condensed sequence, Lycian nappes, Neotethys, Menderes Massif, Turkey

İzmir Kuzeyinde Kondanse Bir Mesozoyik İstif: Bornova Fliş Zonu İçerisinde Anatolid-Torid Karbonat Platformunun Bir Parçası

Özet: Menderes Masifi'nin kuzeybatısında yer alan Bornova Fliş Zonu, en Geç Kretase–Paleosen yaşlı çok makaslanmış klastik bir hamur içinde yer alan değişik büyüklüklerde kireçtaşı, bazalt, serpentinit ve çört bloklarından oluşur. Bu makalede Bigadiç'in 27 km güneybatısında, Urbut Köyü çevresinde mostra veren bir kireçtaşı bloğundan bir kesit tanımlanmaktadır. Seksenbir metre kalınlıktaki istif, massif-kalın tabakalı Üst Triyas karbonatları ile başlar. Bu karbonatlar içindeki foraminifer faunası ve megalodontlar Geç Noriyen–Resiyen yaşını vermektedir. Üst Triyas karbonatları üzerine uyumsuzlukla 19 m kalınlıkta kondanse, yarı-pelajik ve içinde stratigrafik boşluklar bulunan Tithoniyen–Albiyen yaşlı kireçtaşları gelir. Bunlar üzerinde yine uyumsuzlukla kırmızı, pembe, çört yumrulu, ince tabakalı Geç Kretase yaşlı pelajik kireçtaşları yer alır. Asgari kalınlığı 50 metre olan Üst Kretase kireçtaşlarının tabanından alınan numuneler Geç Senomaniyen yaşını veren foraminiferler kapsar; üstte ise Erken–Orta Turoniyen yaşlı pelajik kireçtaşları bulunur. Turoniyen yaşlı pelajik kireçtaşları içerisinde Valanjiniyen ve Geç Triyas yaşlı taneler ve çapı beş metreyi bulan Üst Triyas kireçtaşı blokları ile daha küçük Titoniyen blokları yer alır. Urbut kesitinin stratigrafisi Likya naplarında tanımlanan Domuzdağ Birimi'nin ve Orta Toroslar'da yer alan Boyalı Tepe istifinin stratigrafisine yakın benzerlik sunar. Her üç birimde de altta Geç Triyas yaşlı neritik kireçtaşları yer alır. Bunların üzerinde en geç Jura–Erken Kretase yaşlı pelajik kireçtaşları uyumsuzlukla gelmektedir. Pelajik Üst Kretase kireçtaşları Alt Kretase karbonatlarını veya doğrudan Üst Triyas kireçtaşlarını uyumsuzlukla örter. Urbut istifi Anatolid-Torid karbonat platformunun değişik zamanlarda çöktüğünü göstermektedir. Geç Senomaniyen'deki en son parçalanma muhtemelen ofiyolit yerleşmesine bağlıdır. Urbut istifi Likya naplarının ve benzer allokton birimlerin Menderes Masifi'nin kuzeybatısından geldiği görüşüne destek vermektedir.

Anahtar Sözcükler: Bornova Fliş Zonu, Anatolid-Torid karbonat platformu, Mesozoyik kondanse istif, Likya napları, Neotetis, Menderes Masifi, Türkiye

Introduction

Between the Late Triassic and Late Cretaceous the Anatolide-Tauride Block was part of a very large and extensive carbonate platform. Large sections of this carbonate platform along the northern margin of the Anatolide-Tauride Block were intensely deformed and metamorphosed during the Late Cretaceous ophiolite obduction and Tertiary continental collision. Biostratigraphic information on the evolution of the Anatolide-Tauride carbonate platform is therefore scarce in western and central Anatolia. One tectonic belt on the northern margin of the Anatolide-Tauride Block, which escaped Tertiary metamorphism is the Bornova Flysch Zone, which forms a 50 to 90-km-wide and ~230-km-long tectonic zone between the Menderes Massif and the İzmir-Ankara suture (Figure 1). The Bornova Flysch Zone consists of chaotically deformed upper Maastrichtian–Lower Paleocene graywacke and shale with blocks of Mesozoic limestone, mafic volcanic rock, radiolarian chert and serpentinite (Erdoğan 1990a, b; Okay & Siyako 1993; Okay *et al.* 1996). Many of the blocks must have been initially olistoliths but were subsequently tectonized. The size of the Mesozoic limestone blocks can be as large as 10 km or more, although some of the large 'blocks' may consist of tectonically juxtaposed smaller blocks. The proportion of the ophiolitic clasts in the sheared clastic matrix increases eastward, and the Bornova flysch passes laterally to an

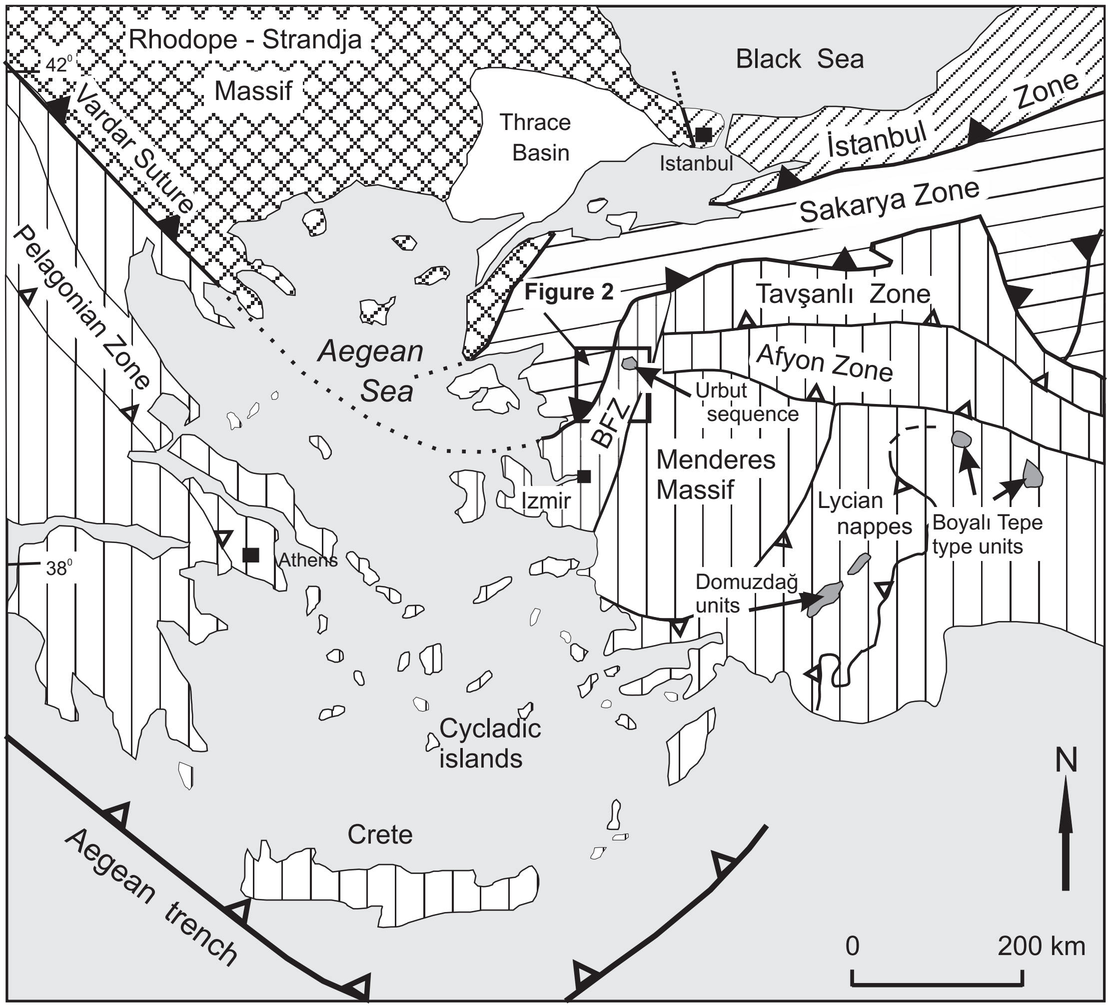

Figure 1. Tectonic map of the Aegean region showing the location of the area studied, and the outcrops of the Boyalı Tepe and Domuzdağ type sequences in the Taurus nappes. BFZ– Bornova Flysch Zone.

ophiolitic mélange in the region of Kepsut, Bigadiç and Sındırgı (Figure 2). In the east, the Bornova Flysch Zone is in contact with the Menderes Massif along post-Eocene normal faults.

The Bornova Flysch Zone has formed by the rapid foundering and destruction of the Anatolide-Tauride carbonate platform during the Maastrichtian–Early Paleocene. Large sections of relatively intact carbonate platform are exposed on the island of Chios and on the adjacent Karaburun Peninsula (Figure 1), where the stratigraphy is also most complete (Besenecker *et al.* 1969; Brinkmann *et al.* 1972; Erdoğan *et al.* 1990). In the Karaburun Peninsula a minimum 300-m-thick Carboniferous neritic limestones are unconformably overlain by an over 2000-m-thick, very heterogeneous, Lower to Middle Triassic sequence of pelagic cherty limestone, radiolarian chert, mafic lava, tuff, sandstone, mudstone, grain and debris flows with Carboniferous limestone blocks (Erdoğan *et al.* 1990). This Scythian–Anisian sequence, which formed during the rifting episode of the Neotethyan ocean, is overlain by over 4-km-thick Ladinian to Albian platform carbonates. The age of the platform carbonates ranges up to Turonian in the limestone blocks farther north (Poisson & Şahinci 1988). Upper Cretaceous red pelagic limestones, representing the foundering of the carbonate platform, overlie unconformably the platform carbonates, cutting down into the Upper Triassic limestones. The Cretaceous pelagic limestones must have been originally overlain by flysch sediments, however, due to later strong deformation, the carbonates now occur as blocks in the sheared greywacke and shale of the Bornova flysch. The flysch and the blocks are unconformably overlain by undeformed upper Lower Eocene (late Cuisian) neritic limestones in the region north of Akhisar (Figure 2, Akdeniz 1980; Önoğlu 2000). This constrains the age of the deformation of the carbonate platform as Late Paleocene–Early Eocene. It is noteworthy that although the Bornova Flysch Zone must have been located at a Mesozoic continental margin, Mesozoic continental slope and rise deposits are rare.

The Urbut Mesozoic Condensed Section

Most of the blocks in the Bornova Flysch Zone consists of massive Upper Triassic platform carbonates. An interesting section, with Upper Triassic, Upper Jurassic–Lower Cretaceous and Upper Cretaceous limestones in stratigraphic continuity, is present near the village Urbut (Yazören), 27 km southwest of Bigadiç (Figure 2). The area around Urbut village consists of Mesozoic carbonates surrounded by volcanic and volcanoclastic rocks, and acidic tuffs of Neogene age (Figure 3). As in most regions of the Bornova Flysch Zone, massive to thickly-bedded grey Upper Triassic neritic limestones constitute most of the carbonates. However, a few hundred metres north of Urbut, the Upper Triassic carbonates are overlain, through a thin interval of Upper Jurassic–Lower Cretaceous pink limestones, by red, pink, thinly bedded, micritic pelagic limestones of early Late Cretaceous age. A stratigraphic section displaying the characteristic features of this succession was measured north of Urbut (Figure 4).

The measured section starts with grey, medium- to thickly-bedded limestones of Late Triassic age (Figure 4). These limestones are composed of pelletoidal wackestones or wackestones to grainstones containing laminated micritic clasts, megalodont fragments, foraminifers, *Thaumatoporella* and ostracods at the base, and wackstones to bindstones and pelletoidal and laminated dismicrites with geopetal structures at the top. The sedimentological and palaeontological features indicate a peritidal depositional setting. The samples (1–5, Figure 4) collected from this interval reveal a rich association of benthic foraminifera including *Triasina hantkeni, Auloconus permodiscoides, Aulotortus friedli, A. gaschei, A. impressus, A.* gr. *sinuosus, A. minutus, A.* spp., *Earlandia* sp., *Gandinella* sp., *Endotriada* sp., *Trochammina* sp., *Duotaxis* ? sp., Ataxophragmiidae, *Meandrospira* sp., *Agathammina austroalpina* ?, *Agathammina* sp. and lagenids, usually associated with *Thaumatoporella parvovesiculifera* (Plate 1). On the basis of the stratigraphic index foraminifer *T. hantkeni* (Al-Shaibani *et al*. 1982; Martini *et al*. 2004), which occurs persistently in the Urbut samples, a Late Norian (Sevatian) to Rhaetian age (*T. hantkeni* Zone) can be proposed for the Triassic portion of the studied section.

Although the overlying limestones (samples 6–10, Figure 4) are hardly distinguishable from the Upper Triassic carbonates in the field, except in their grey to pink colour, a pronounced gap encompassing nearly the entire Jurassic separates them from the Upper Norian to Rhaetian carbonates. This portion of the section measuring about 7.5 m in thickness is composed of

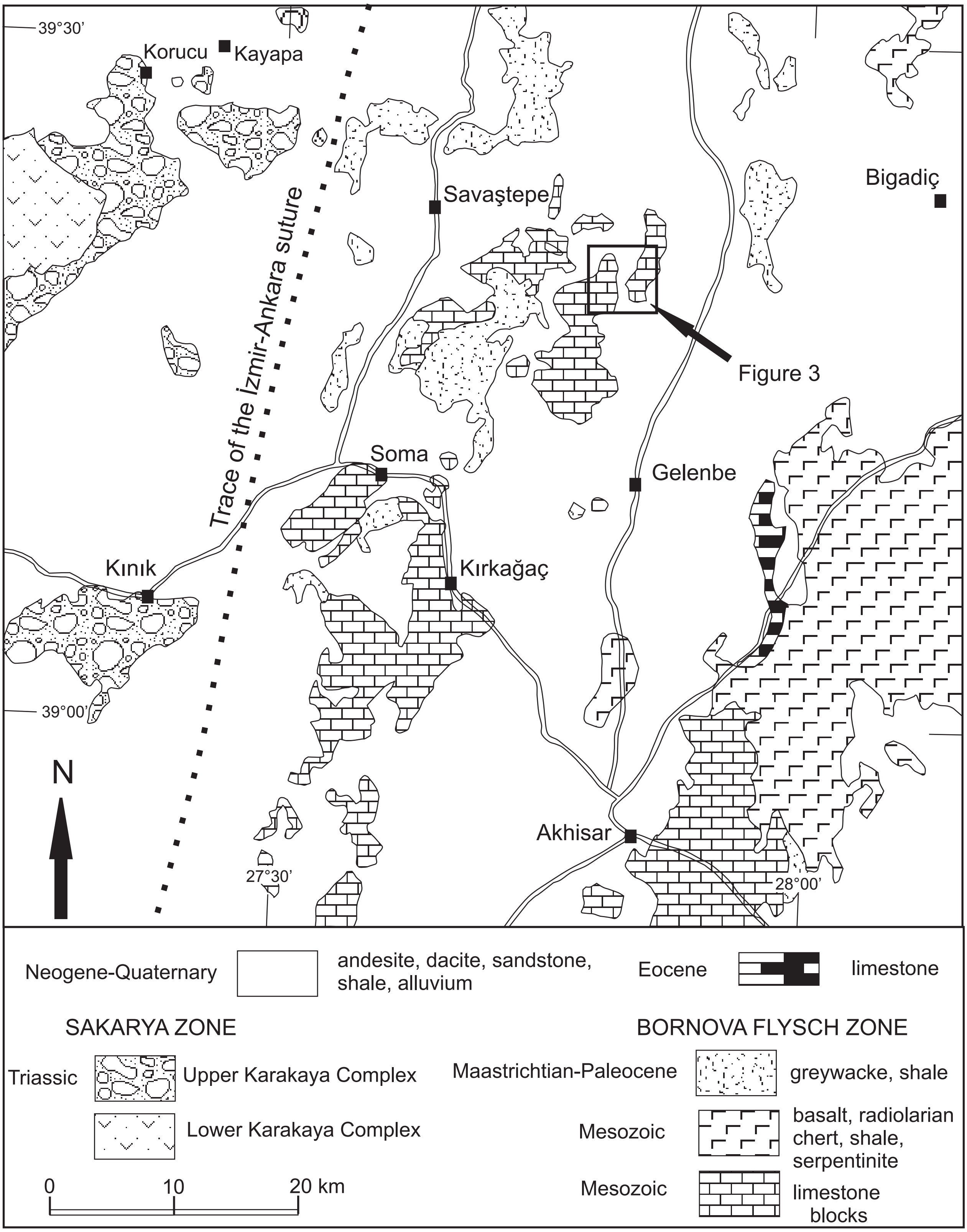

Figure 2. Geological map of the Savaştepe-Akhisar area (modified from Okay *et al.* 1996; Konak 2002).

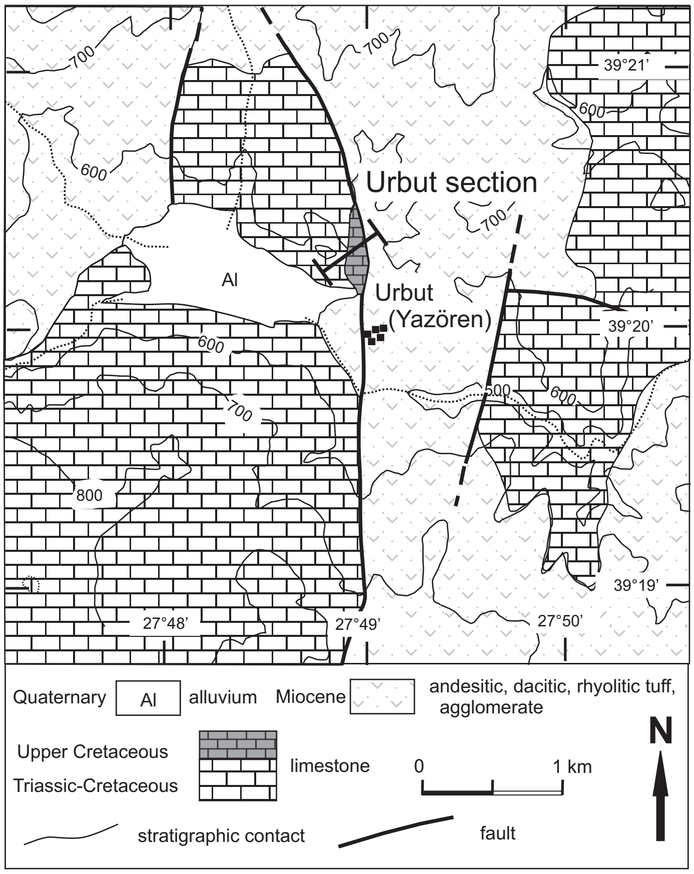

Figure 3. Geological map of the Urbut region. Contours at every 100 metres. For location see Figure 2.

packstones to grainstones rich in thin-shelled pelecypods, except in the uppermost level (sample 10), which is still a packstone but is composed predominantly of the fragments of the free floating crinoid *Saccocoma* sp. Samples 6–9 contain a rather poorly diversified microfauna including *Patellina* sp., *Palaeomiliolina* or *Ophthalmidium* sp., *Lenticulina* sp., other lagenides, *Globochaete alpina* and *Cadosina* sp (Plate 2). This association, immediately underlying the *Saccocoma*-bearing level, probably belongs to the Tithonian (Figure 4). Sample 10 with abundant *Saccocoma*, contains also protoglobigerinids, *Globuligerina* ex gr. *oxfordiana* and *Globuligerina* sp. (high trochospiral forms). The genus *Globuligerina* is known in Turkey from the Callovian to Kimmeridgian interval (Altıner 1991). However, its occurrence may extend higher, as it is recently reported by Premoli Silva & Verga (2004) from the Berriasian and Valanginian. Therefore, it is not surprising to discover *Globuligerina* in the *Saccocoma*-bearing levels in Turkey.

In the Urbut section, the well-determined Tithonian is characterized by a visible facies change from grey to pink, medium- to thickly-bedded limestones to thinly- to medium-bedded, pink micritic limestones (Figure 4). Samples 11–13 collected from the lower part of this condensed interval, only about 11 m thick, are bioturbated packstones rich in *Saccocoma sp*. According to Nicosia & Parisi (1979) species of *Saccocoma* occur at two different intervals in the Late Jurassic. A lower group ranges from Middle Oxfordian to Early Kimmeridgian; the other one is confined to Tithonian. In Turkey, Altıner (1991) defined the *Saccocoma* Subzone in the Tithonian with the same population (probably *S. tenella*) as discovered in the Urbut section. According to Altıner (1991), this subzone contains an Early Tithonian

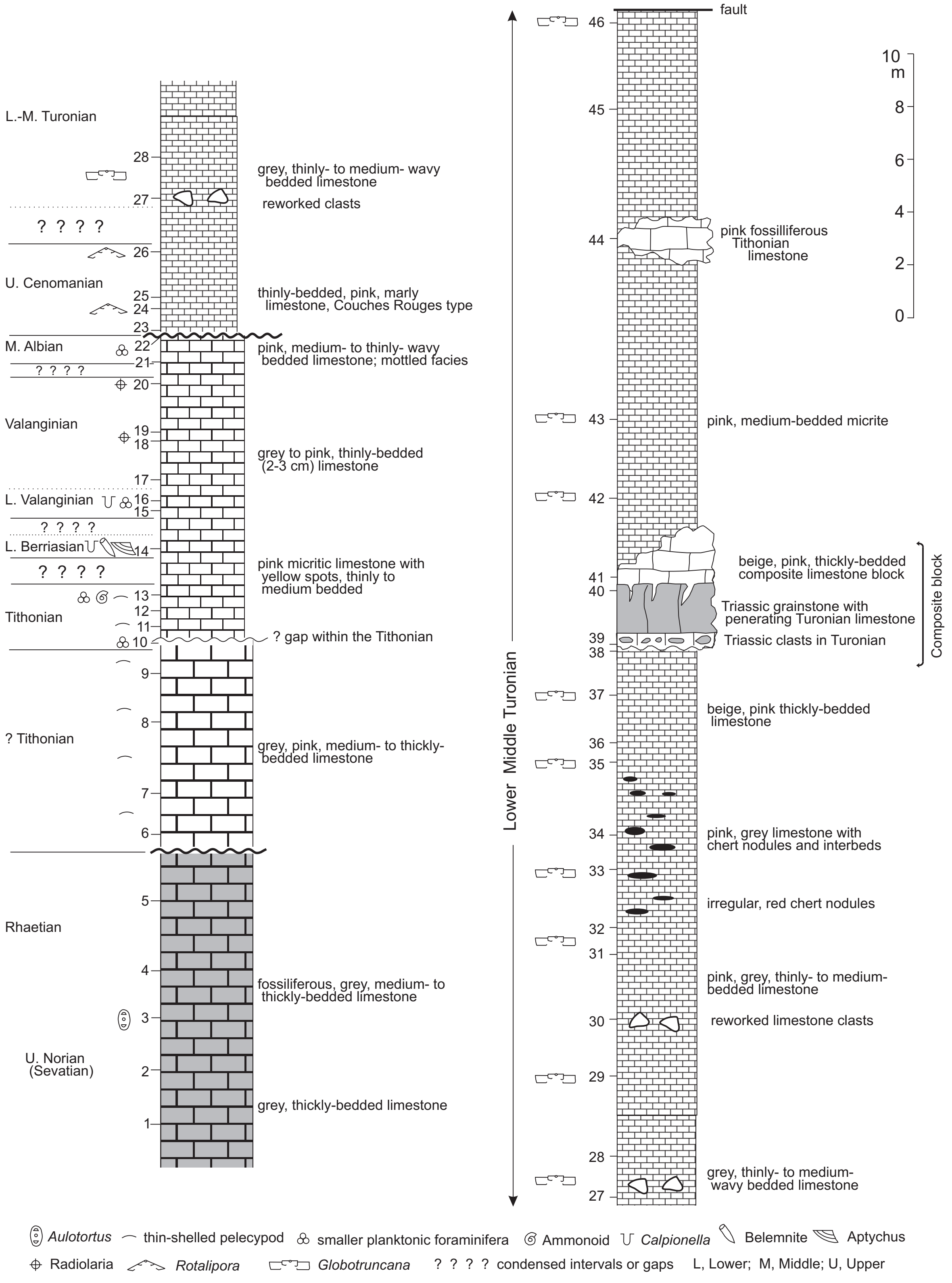

Figure 4. Measured stratigraphic section from the Urbut locality.

ammonoid (*Subplanites* cf. *reisi*, see also Cope 1991) while the upper part of the subzone is characterized by the presence of the calpionellid *Chitinoidella* ranging from Middle Tithonian to early Late Tithonian. In the Urbut section, the *Saccocoma* Subzone contains a limited microfauna including *Spirillina* sp., *Lenticulina* sp., other lagenids, *Globochaete alpina* and *Cadosina* ex gr. *lapidosa* (*C. lapidosa, C. sublapidosa, C. tenuis, C. carpathica*) of Tithonian age (Plate 2).

Calpionellid limestones overlying the Tithonian limestones with *Saccocoma* sp. represent the most condensed portion of the Urbut section and probably comprise hiatuses (Figure 4). Sample 14 collected from this interval is a wackestone with calpionellids, *Aptychus* and ammonoids. Calpionellids comprise *Calpionella alpina, Crassicollaria parvula, Tintinopsella carpathica, Remaniella* ? sp., associated with *Lenticulina* sp., other lagenids, *Cadosina* ex gr. *lapidosa* and *Globochaete alpina* (Plate 2). This calpionellid association corresponds to the lower part of the calpionellid B Zone of Altıner & Özkan (1991), recently equated by Grün & Blau (1997) with their *Calpionella alpina* Zone of Early Berriasian age. Samples 15 and 16 collected from calpionellid limestones yield a classical association of calpionellids of Early Valanginian age comprising *Calpionellites darderi, C. coronatus, Calpionellopsis oblonga, Remaniella cadischiana, Praecalpionellites filipescui, P. dadayi, P. siriniaensis, Tintinopsella longa* and *T. carpathica* (Plate 2). These levels are the equivalent of the calpionellid E Zone of Altıner & Özkan (1991) which could be correlated with the *Calpionellites darderi* and *C. major* zones of Grün & Blau (1997). In the Urbut section, Lower Valanginian limestones with calpionellids also contain the earliest Cretaceous planktonic foraminifer *Caucasella hoterivica* and *Globuligerina* sp. (Plate 2). In the Cretaceous planktonic foraminiferal zonation, these levels should be the upper part of the *Caucasella hoterivica* Zone of Premoli Silva & Verga (2004) assigned to the Berriasian to early Valanginian age.

The condensed interval in the Urbut section continues with Valanginian beds (samples 17–20, Figure 4) characterized by lime mudstones and bioturbated wackestones containing radiolaria, rare planktonic foraminifers and calpionellids. Diagnostic forms recognized in this succession are *Caucasella hoterivica, Gorbachikella* sp., *Hedbergella sigali* and the calpionellid *Tintinopsella* (Plate 2). These levels correspond to the lowermost part of the *Hedbergella sigali-H. intermedia* Zone of Premoli Silva & Verga (2004) and the calpionellid F Zone of Altıner & Özkan (1991) assigned to the Valanginian.

Above the Valangian beds the interval between samples 20 and 21 is again an extremely condensed section possibly with gaps in the succession (Figure 4). Measuring only one metre in thickness, this interval corresponds to the Hauterivian, Barremian, Aptian and the Lower Albian, and is overlain by Middle Albian wackestones and packstones extremely rich in planktonic foraminifers (samples 21 and 22). Taxa identified comprise *Muricohedbergella planispira, M. rischi, M. simplex, M. delrioensis, M.*spp.*, Loeblichella hessi, Macroglobigerinelloides bentonensis, Biticinella subbreggiensis ?, Ticinella primula, T. raynaudi, T. praeticinensis, T. roberti, T.* sp. (Plate 3). This part of the succession belongs to the *Ticinella praeticinensis* Subzone of the *Ticinella breggiensis* Zone, known as the standard of the Middle Albian biostratigraphy.

The carbonates in the uppermost part of the Urbut section consist of thinly- to medium-bedded pink, grey micrites with chert nodules, with a thickness of at least 50 m (Figure 4). The clearly visible facies change in the field from medium- to thinly-, wavy-bedded micritic limestones of Middle Albian age to thinly-bedded, pink argillaceous micritic limestone of Late Cenomanian age is a gap corresponding to the *Rotalipora subticinensis, R. ticinensis* and *R. appenninica* zones of Middle Albian to earliest Cenomanian and the *Rotalipora globotruncanoides* and *R. reicheli* zones of Early to Middle Cenomanian. The Upper Cenomanian sequence (including probably the uppermost Middle Cenomanian) is highly condensed (Figure 4, samples 23–26) and contains a rich association of planktonic foraminifers including *Rotalipora cushmani, R. apenninica, R. globotruncanoides, R.greenhornensis, R. deecki, R.* spp., *Praeglobotruncana delrioensis, P. stephani, P. gibba, Dicarinella algeriana, D. imbricata, Whiteinella* sp., *Muricohedbergella planispira, M. simplex, M.* spp., *Macroglobigerinelloides* sp., *Heterohelix* spp (Plate 4). The Upper Cenomanian corresponds to the *Rotalipora greenhornensis* and *Dicarinella algeriana* subzones of the *Rotalipora cushmani* Zone of the standard planktonic foraminiferal biozonation scheme (Premoli Silva & Verga 2004).

The rest of the Urbut section is composed of grey to pink, thinly- to medium-bedded limestones (samples

27–46) locally with chert nodules, and includes clasts or blocks of limestone derived from the underlying units. It belongs entirely to the *Helvetoglobotruncana helvetica* Zone of the Early to Middle Turonian. The two-meter-thick limestone succession above the last dated Cenomanian bed (sample 26) corresponds to the uppermost levels of the Cenomanian stage and to the lowermost Turonian (upper part of the *Dicarinella algeriana* Subzone of the *Rotalipora cushmani* Zone and the *Whiteinella archaeocretacea* Zone). The Cenomanian–Turonian boundary should lie within this extremely condensed two-meter-thick succession between the samples 26 and 27.

The limestones in the *Helvetoglobotuncana helvetica* Zone (Lower–Middle Turonian) are partly bioturbated wackestones to packstones rich in planktonic foraminifers and calcisphaerulids. The diversified fauna includes *Helvetoglobotruncana helvetica, Marginotruncana coronata, M. pseudolinneiana, M. renzi, M. sigali, M. marginata, M. schneegansi, M. tarfayaensis, M.* spp.*, Whiteinella praehelvetica, W. archaeocretacea, W. paradubia, Dicarinella algeriana, D. canaliculata, D. imbricata, D.* sp., *Falsotruncana* sp., *Muricohedbergella flandrini, M.* spp., *Macroglobigerinellodies* sp., *Schackoina cenomana, Heterohelix globosa, H.* sp., *Pithonella ovalis, Calcisphaerula* sp. (Plate 6).

The reworked clasts and blocks in the Turonian limestones of the Urbut section are of two groups: clasts derived from the Turonian itself and clasts or blocks derived from the older units. The Turonian clasts contain a planktonic foraminiferal assemblage similar to the matrix that surround them; they are frequently observed in samples 27, 30, 38, 39, 41 (Plate 6, Figure 21). In these levels they are associated usually with clasts derived from the older units, which indicate a complex reworking process during the progressive deformation of the northernmost parts of the Tauride carbonate platform in the Turonian. As the more distal parts of the carbonate platform were uplifted and eroded, limestone detritus were transported southward and eastward.

Clasts and blocks derived from the older rocks in the Urbut section are of three types and are found in three different levels of the Lower to Middle Turonian section. The first level (sample 27), immediately overlying the condensed Upper Cenomanian section, contains clasts originating from the Valanginian layers (Plate 6, Figure 22). These clasts, measuring hundreds of micron to one millimetre in size, contain *Gorbachkiella* sp., *Spirillina* sp., *Globochaete alpina* and abundant Radiolaria in a lime mudstone facies, as found typically in the Valanginian of the Urbut section. In the more remarkable second level, 26 m above the unconformity, a block of Upper Triassic–Turonian limestone, about four metres across, occurs within the Turonian micrites (Figure 4). The lowermost bed of this block (sample 39) is a wackestone with abundant clasts of the Sevatian–Rhaetian limestone in a matrix with Early to Middle Turonian planktonic foraminifers (Plate 6, figures 23–25). The allochthonous clasts, millimetre in size, are wackestones to packstones with foraminifers, algae and pelecypods including *Triasina hantkeni*, *Aulotortus* gr. *sinuosus*, *A.* sp. and lagenids. The second sample from this block (sample 40) is a wackestone to packstone including *Aulotortus* gr. *sinuosus, A.* sp., *'Nodosaria' ordinata*, other lagenides and *Thaumatoporella* sp. Microscopic fissures and fractures infilled with Turonian limestone are visible in the Triassic carbonate. Farther up, the Triassic–Turonian block contains an unexpected, well-defined pelagic layer (sample 41) comprising a rich association of Early to Middle Turonian planktonic foraminifers. These unusual facies associations indicate that this block has experienced a secondary reworking process before the final emplacement within the Turonian deposits of the Urbut section. Finally, the third level containing allochtonous material in the Turonian is also a block, assigned to the Early to Middle Tithonian (Figure 4). Sample 44 from this block is a *Saccocoma*-rich packstone, very similar to the Tithonian facies of the Urbut section. The section ends with a fault contact against the Neogene volcanic rocks (Figure 3).

Discussion

The Urbut sequence, only 81 m thick, encompasses a period of ~115 my between the Late Triassic and Late Cretaceous. The sequence is characterized by at least three foundering events affecting the carbonate platform. The two earlier events, at the beginning of Tithonian and within the Tithonian could be related to the development of a passive margin by extensional listric faulting. Similar sequences related to the passive margin development have been described from Atlatic and Tethyan margins (e.g., Bernoulli 1972; Bernoulli *et al*. 1979). On the other hand, the Late Cenomanian foundering and collapse observed in the Urbut section is temporally and most likely causally related to the emplacement of the ophiolite nappes over the northern margin of the Anatolide-Tauride carbonate platform. Isotopic ages from the metamorphic soles of the Anatolian ophiolites, which mark the beginning of the obduction, are generally Cenomanian (between 100 and 95 Ma, e.g., Parlak & Delaloye 1999). In the Urbut section, the Lower to Middle Turonian pelagic limestones contain blocks of the underlying neritic Upper Triassic limestone indicating that the collapse of the carbonate platform persisted into the Turonian. The onset of the pelagic Upper Cretaceous carbonate deposition in the Bornova Flysch Zone shows a general younging towards the southwest. In the well-studied Balıklıova section on the Karaburun peninsula, the base of the Senonian unconformity is dated as Santonian (Brinkmann *et al*. 1977; Erdoğan *et al*. 1990; Tansel 1990). The southward shift in age may reflect the passage of the ophiolite nappe over the Anatolide-Tauride carbonate platform.

Stratigraphically the Urbut section shows close similarities to the Domuzdağ unit in the Lycian nappes and to the Boyalı Tepe unit in the Central Taurides (Figure 1, Şahinci 1976). The Domuzdağ unit forms part of the uppermost Lycian nappe pile, and is tectonically intercalated with the ophiolitic mélanges (Şenel 1997a, b), whereas the Boyalı Tepe unit constitutes part of the uppermost nappes in the Central Taurides (Monod 1977; Gutnic *et al*. 1979; Gökdeniz 1981; Özgül 1997). As in the Urbut section, shallow marine platform carbonates, Norian–Rhaetian in age, form the base of the Domuzdağ and Boyalı Tepe sequences (Figure 5). The Upper Triassic carbonates contain megalodonts, *Thaumatoporella*-type algae and foraminifera such as *Aulotortus friedli*, *A. sinuosa pragsoides* (Brönnimann *et al.* 1970; Gutnic &

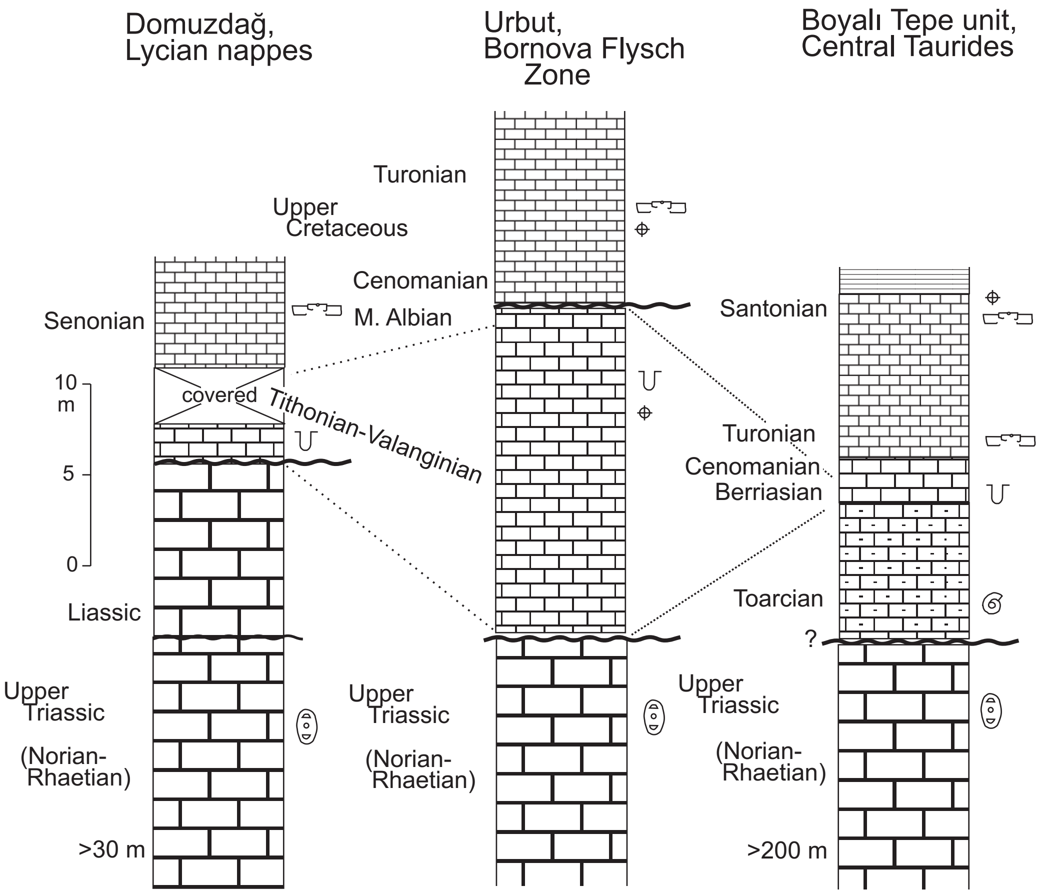

Figure 5. Urbut section compared to the Domuzdağ (Poisson 1977) and Boyalı Tepe (Gutnic & Monod 1970) sections with the same vertical scale. For the explanation of the microfauna see Figure 4.

Monod 1970; Poisson 1977). In the Domuzdağ and Boyalı Tepe units, the Upper Triassic carbonates are overlain by Liassic limestones, about 10 m thick, which are apparently lacking in the Urbut section. The unconformably overlying condensed uppermost Jurassic–lowermost Cretaceous pelagic carbonates are a characteristic feature of all the three units (Figure 5). In the Domuzdağ and Urbut sections, the Tithonian to Lower Cretaceous carbonates share a common calpionellid assemblage of *Tintinnopsella carpathica*, *Calpionella alpina*, *Calpionellopsis oblonga*, *Calpionellites darderi*. Very detailed sampling in the Domuzdağ section has shown that the lowermost Cretaceous pelagic carbonate section extends down the upper Tithonian, which is only 10 cm thick (Poisson 1977). In the Urbut section, the thickness of the Tithonian, including the lower uncertain part, measures about 10 m. In both the Domuzdağ and Urbut sections, the Upper Cretaceous pelagic limestones lie unconformably over the lowermost Cretaceous, and in places directly over the Upper Triassic carbonates. In the Boyalı Tepe section, there is apparently continuous sedimentation between the Cenomanian and Santonian.

Conclusions

The Urbut section shows that condensed pelagic sedimentation occurred during the Tithonian–Early Cretaceous in the outer margins of the Anatolide-Tauride carbonate platform. The intra Jurassic foundering events observed in the sequence is related to the development of the passive margin, wheras the Late Cenomanian collapse is caused by the initiation of Cenomanian ophiolite obduction over the Anatolide-Tauride carbonate platform.

The Urbut Mesozoic carbonate section is similar to that of the Domuzdağ unit in the Lycian nappes and the Boyalı Tepe unit of the Central Taurides, located more than 300 km southeast. These units are characterized by a condensed pelagic sequence of Late Jurassic to earliest Cretaceous age, which lies unconformably over the Upper Triassic carbonates. The stratigraphic and faunal similarity suggests that during the Mesozoic all were located close along the margin of the Anatolide-Tauride carbonate platform. This gives further support to the derivation of the Lycian nappes from northwest of the Menderes Massif (e.g., Brunn *et al*. 1976; Gutnic *et al*. 1979).

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PLATE 1

All specimens are from the Upper Norian (Sevatian)–Rhaetian of the Urbut section.

1–3 *Triasina hantkeni* MAJZON
4–5 *Aulotortus* gr. *sinuosus* (WEYNSCHENK)
6–7, 8 ? *Aulotortus friedli* (KRISTAN-TOLLMANN)
9–10 *Aulotortus* spp.
11–12 *Aulotortus minutus* (KOEHN-ZANINETTI)
13–15 *Aulotortus gaschei* (KOEHN-ZANINETTI & BRÖNNIMANN)
16 *Aulotortus impressus* (KRISTAN-TOLLMANN)
17 *Aulotortus permodiscoides* (OBERHAUSER)
18 *Gandinella* sp.
19 *Agathammina* sp.
20 *Thaumatoporella parvovesiculifera* RAINERI

1, 15: sample UR-1/2; 2, 4, 16, 20: UR-2/2; 3, 6, 17: UR-2/1; 5, 19: UR-5/2; 7, 9, 11, 14: UR-4/2; 8, 12–13: UR-4/1; 10–18: UR-3/2.

1–4, 6, 8, 15–17, 20: X 45; 5, 7, 9–14, 18-19: X 91.

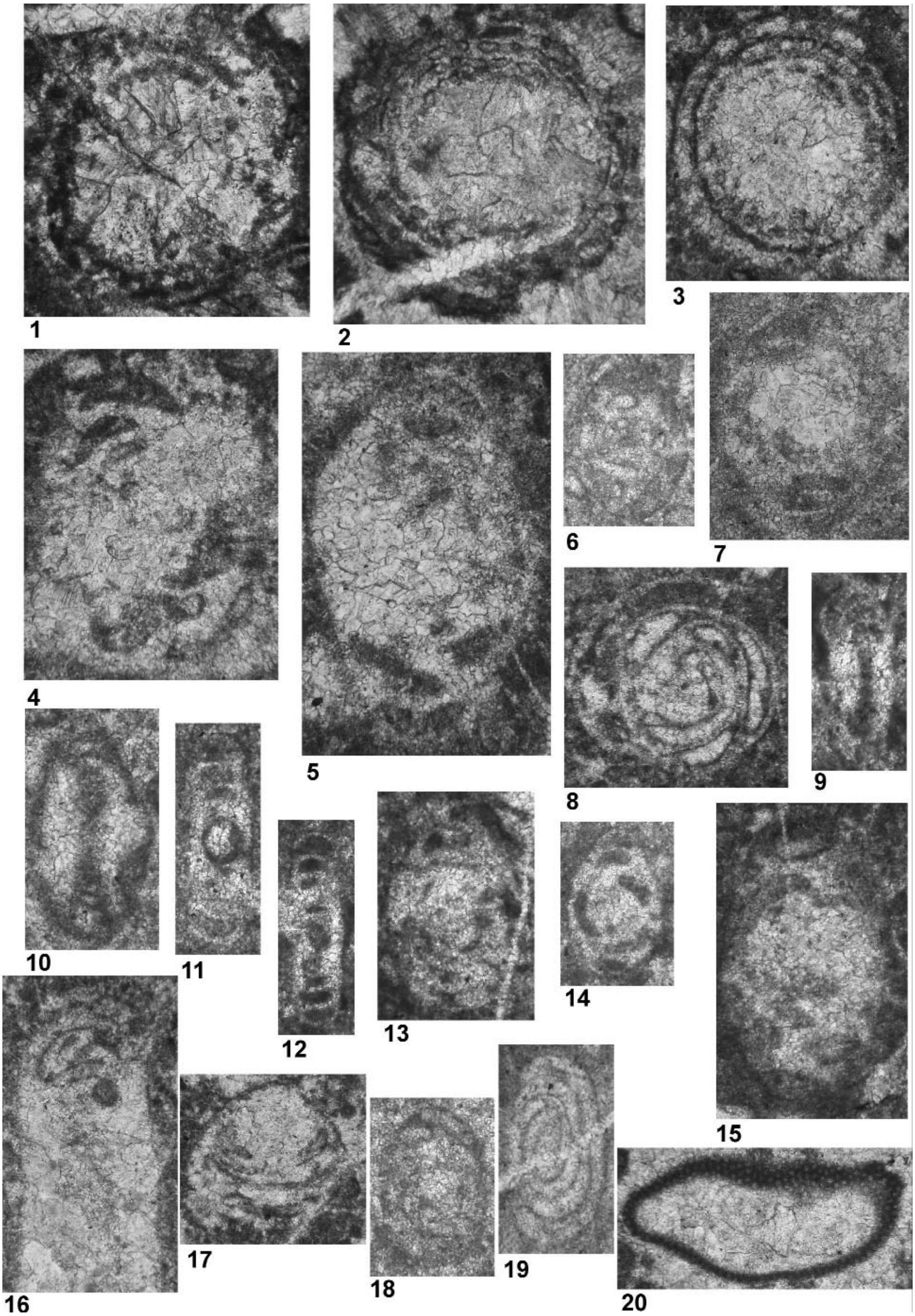
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PLATE 2

All specimens are from the Tithonian–Valanginian of the Urbut section.

1 *Patellina* sp.
2–3 *Spirillina* sp.
4 Lagenid foraminifera
5–7 *Palaeomiliolina* or *Ophthalmidium* sp.
8 Thin-shelled pelecypods with *Globochaete alpina* LOMBARD.
9–13 *Saccocoma* sp.
14–19 *Cadosina* ex gr. *lapidosa* VOGLER
20–22, 25 *Globuligerina* gr. *oxfordiana* (GRIGELIS)
23–24 *Globuligerina* sp.
26–31 *Caucasella hoterivica* (SUBBOTINA)
32–39 *Gorbachikella* spp.
40 *Hedbergella sigali* MOULLADE
41–46 *Calpionella alpina* LORENZ
47–49 *Crassicollaria parvula* REMANE
50–52 *Tintinopsella carpathica* (MURGEANU & FILIPESCU)
53–54 *Tintinopsella longa* (COLOM)
55 *Calpionellopsis oblonga* (CADISCH)
56–61 *Calpionellites darderi* (COLOM)
62 *Calpionellites coronatus* TREJO
63 *Praecalpionellites filipescui* (POP)
64 *Praecalpionellites dadayi* (KNAUER)
65 *Praecalpionellites siriniaensis* POP

1, 5–6, 8: sample UR-6/1; 2, 16: UR-12/2; 3-4: UR-11/2; 7: UR-6/2; 9, 12, 18: UR-12/1; 10–11, 19: UR-13/2; 13: UR-11/1; 14–15, 17: UR-13/1; 20–21: UR-10/1; 22–25: UR-10/2; 26, 28–29, 31, 52–53, 62: UR-16/2 ; 27, 30, 50–51, 54, 58–61, 62: UR-16/1; 32, 35, 39–40: UR-19/2; 33–34, 36–38: UR-19/1; 41–42, 44-48: UR-14/1; 43, 49:UR-14/2; 55, 64–65:UR-15/2; 56-57:UR-15/1.

1–12, 20–40: X 91; 13: X 45; 14–19, 41-65: X 168.

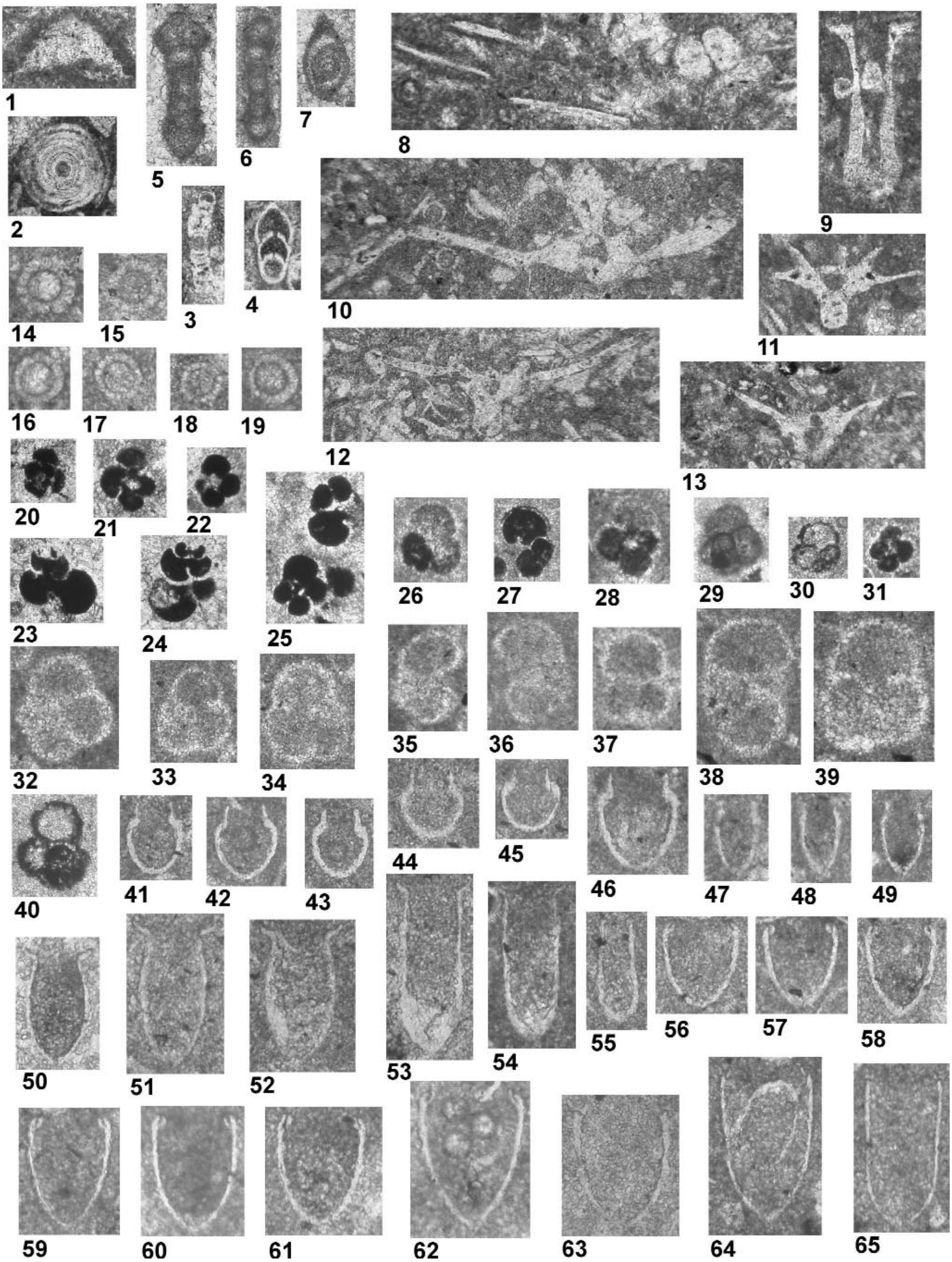
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PLATE 3

All specimens are from the Middle Albian of the Urbut section.

1 *Muricohedbergella simplex* (MORROW)
2 *Muricohedbergella* sp.
3–8 *Muricohedbergella rischi* (MOULLADE)
9–11 *Muricohedbergella planispira* (TAPPAN)
12 *Muricohedbergella* sp.
13 Muricohedbergella delrioensis (CARSEY)
14 *Muricohedbergella* sp.
15–16 *Ticinella* sp.
17 *Loeblichella hessi* PESSAGNO
18–22 *Ticinella praeticinensis* SIGAL
23–27 *Ticinella primula* LUTERBACHER
28 *Ticinella raynaudi* SIGAL
29–35,38 *Ticinella* sp.
36–37 *Ticinella roberti* (GANDOLFI)
39–44 *Biticinella subbreggiensis* SIGAL ?
45–47 *Macroglobigerinelloides bentonensis* (MORROW)

1, 6, 13, 25–27, 37–38, 43, 47: sample UR-21/2; 2, 4–5, 10, 16, 21, 33–36, 39, 41: UR-22/1; 3, 14–15, 17, 20, 22–23, 28-30, 40: UR-22/2; 7–9, 11–12, 18–19, 24, 31–32, 42, 44–46: UR-21/1.

1–47: X 91.

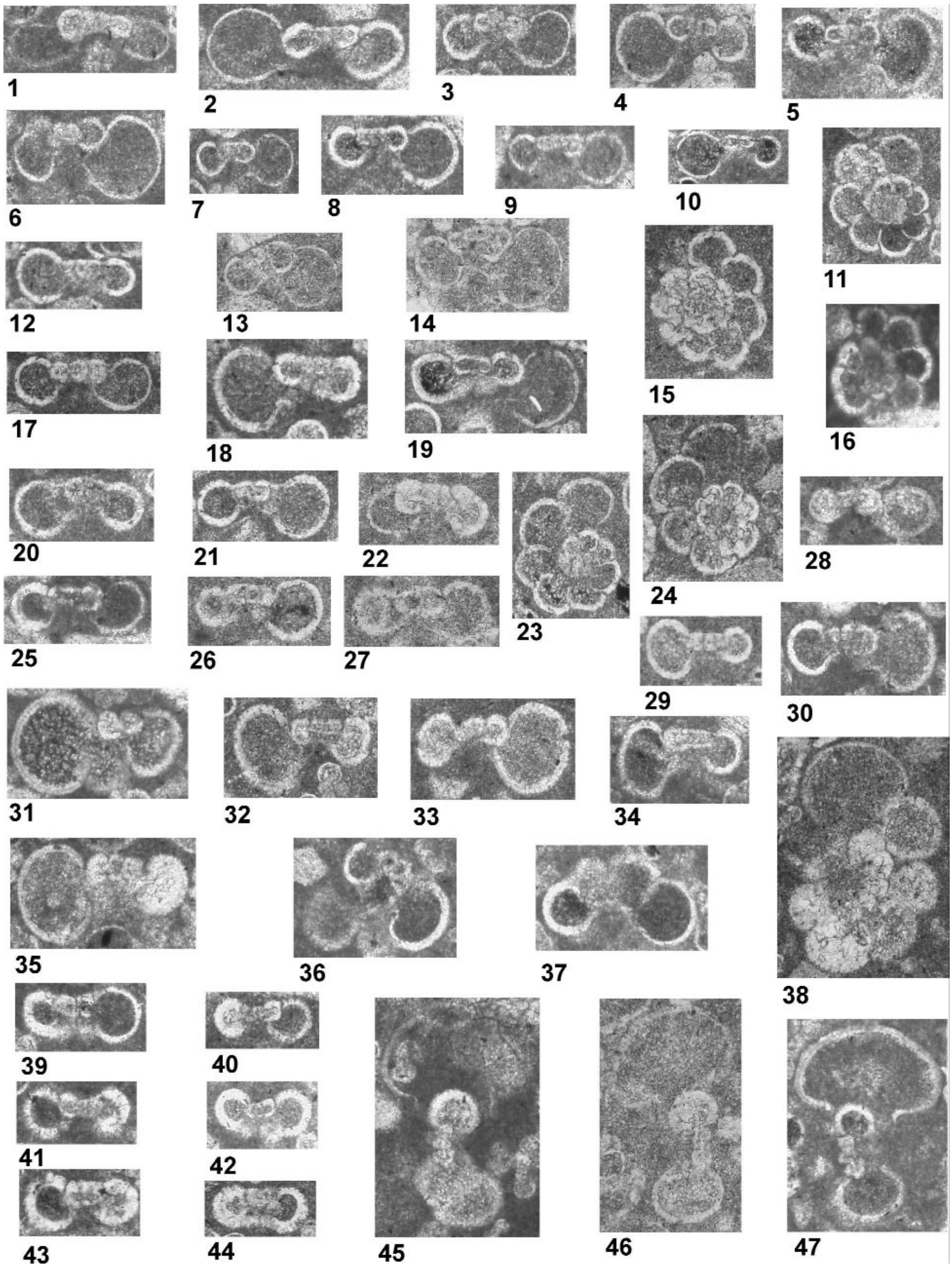
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PLATE 4

All specimens are from the Upper Cenomanian of the Urbut section.

1–4 *Rotalipora cushmani* (MORROW)
5–8 *Rotalipora deecki* (FRANKE)
9 *Rotalipora* sp.
10 *Rotalipora globotruncanoides* SIGAL
11–14 *Rotalipora greenhornensis* (MORROW)
15 *Rotalipora apenninica* (RENZ)
16 *Praeglobotruncana delrioensis* (PLUMMER)
17–21 *Praeglobotruncana stephani* (GANDOLFI)
22–23 *Praeglobotruncana gibba* KLAUS
24–25 *Dicarinella algeriana* (CARON)
26–27 *Dicarinella imbricata* (MONROD)

1, 11, 21: sample UR-25/2; 2–3: UR-23/2 ; 4, 9, 18-20, 22, 24: UR-25/1; 5, 7, 11, 14, 25: UR-26/1; 6, 8, 15–17, 23: UR-24/2; 10: UR-23/1; 12-13, 26: UR-26/2.

1–27: X 91.

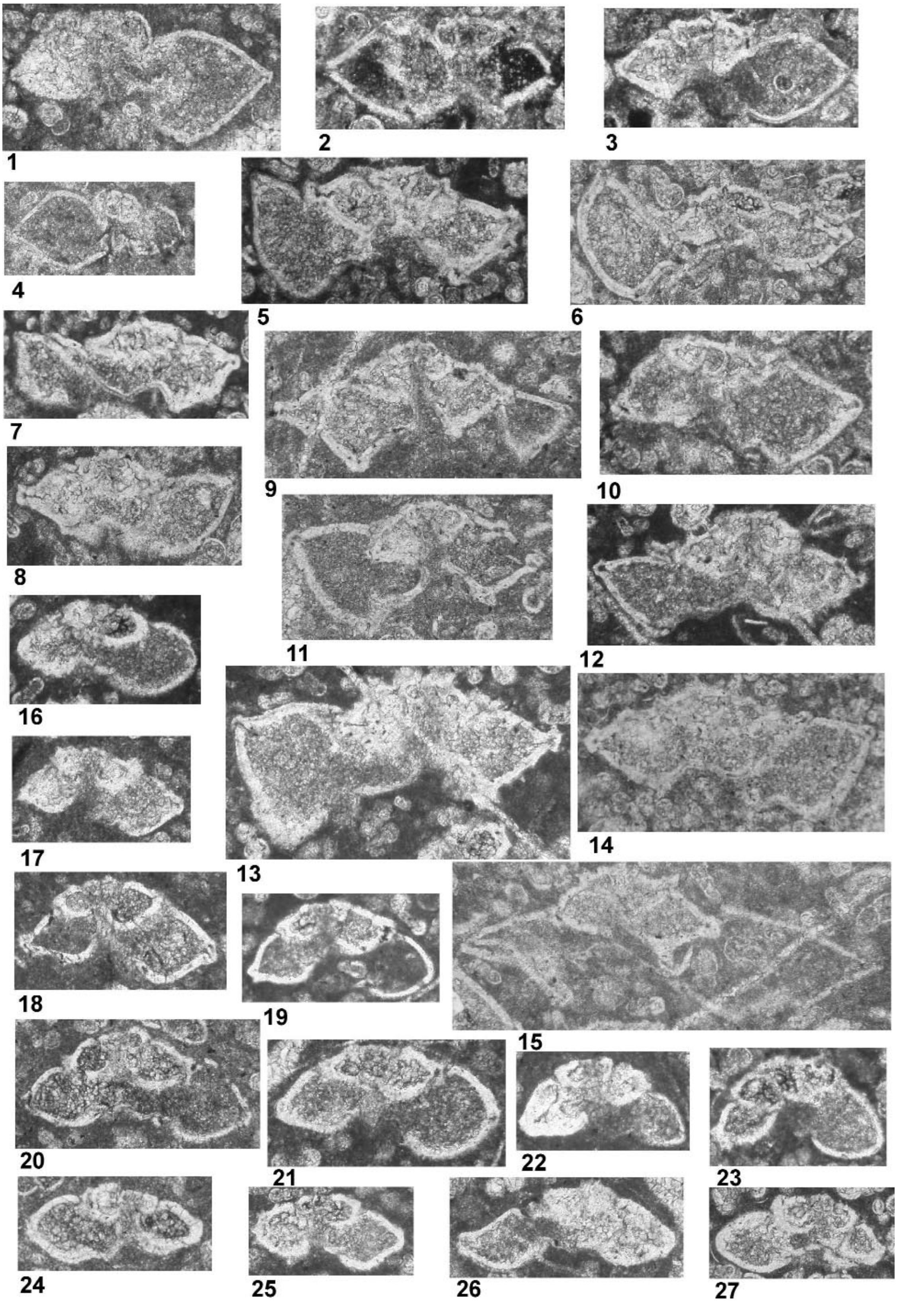
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PLATE 5

All specimens are form the Lower–Middle Turonian of the Urbut section.

1–5 *Helvetoglobotruncana helvetica* (BOLLI)
6–12 *Marginotruncana pseudolinneiana* PESSAGNO
13–16 *Marginotruncana coronata* (BOLLI)
17 *Marginotruncana tarfayaensis* (LEHMANN)
18 *Marginotruncana sinuosa* PORTHAULT
19–20, 22–23 *Marginotruncana renzi* (GANDOLFI)
21 *Marginotruncana schneegansi* (SIGAL)
24–26 *Marginotruncana sigali* (REICHEL)

1, 4, 13, 24: sample UR-41/1; 2, 18, 25–26: UR-38/2; 3, 21: UR-41/2; 5 : UR-39/1; 6: UR-43/1; 7: UR-27/1; 8, 11, 22: UR-30/2; 9, 12, 16: UR-27/2; 10, 15: UR-36/1; 17: UR-45/2; 19: UR-34/2; 20: UR-33/1; 23: UR-36/2.

1–26: X 91.

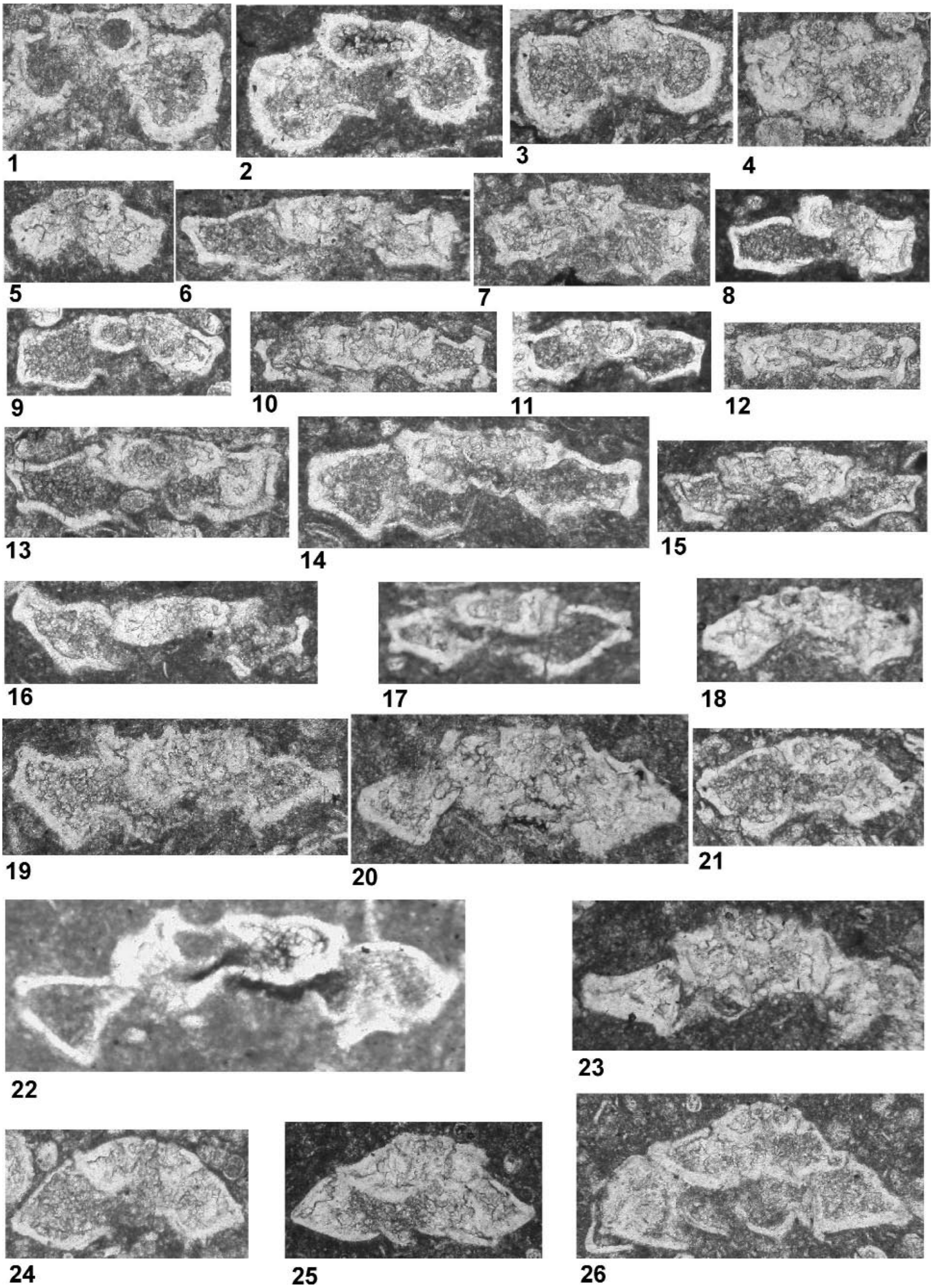
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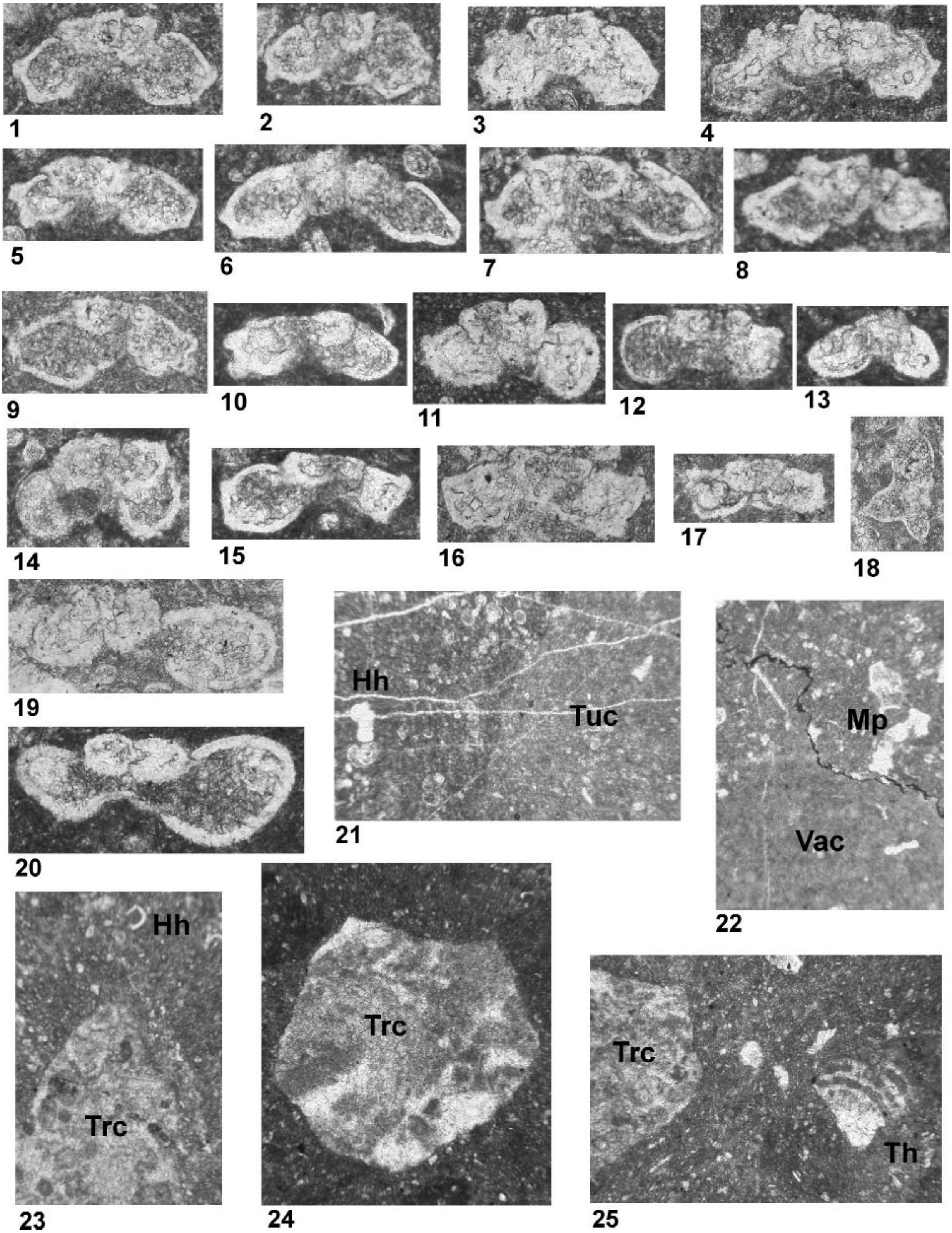
PLATE 6

All specimens and microfacies photomicrographs are from the Lower–Middle Turonian of the Urbut section.

1–5 *Marginotruncana marginata* (REUSS)
6–8 *Dicarinella imbricata* (MONROD)
9–10 *Dicarinella algeriana* (CARON)
11–12 *Whiteinella praehelvetica* (TRUJILLO)
13 *Whiteinella archaeocretacea* PESSAGNO
14 *Whiteinella paradubia* (SIGAL)
15–17 *Dicarinella canaliculata* (REUSS)
18 *Schackoina cenomana* SCHACKO
19 *Muricohedbergella flandrini* (PORTHAULT)
20 *Muricohedbergella* sp.
21 Lower–Middle Turonian clast (Tuc) within the Lower–Middle Turonian matrix. Note *Helvetoglobotruncana helvetica* (BOLLI) (Hh) on the left.
22 Valanginian clast (Vac) within the Lower–Middle Turonian matrix. Note section of *Marginotruncana* gr. *pseudolinneiana* PESSAGNO (Mp) in the matrix.
23 Upper Norian (Sevatian)–Rhaetian clast (Trc) within the Lower–Middle Turonian matrix. Note the broken chamber of *Helvetoglobotruncana helvetica* (BOLLI) (Hh) in the upper of the photomicrograph indicating reworking also in the Turonian facies.
24 Upper Norian (Sevatian)–Rhaetian clast (Trc) within the Lower–Middle Turonian facies.
25 Upper Norian (Sevatian)–Rhaetian clasts (Trc) within the Lower–Middle Turonian matrix. Note the broken test of *Triasina hantkeni* MAJZON (Th) derived from the Upper Triassic shallow water limestones.

1, 4, 10, 21: sample UR-30/1; 2, 23: UR-39/1; 3, 24–25: UR-39/2; 5, 17, 19–20: UR-27/2; 6: UR-31/2; 7, 14: UR-41/1; 8, 9, 11: UR-38/2; 12, 22: UR-27/1; 13: UR-37/1; 15-16: UR-32/1; 18: UR-38/1.

1–20: X 91; 21–25: X 28.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