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Vestiges of atoll-like formations in the Lower Cretaceous of the Mecsek Mountains, Hungary

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Macro- and microfossils and microfacies of a few Lower Cretaceous sections in the Mecsek Mountains have been studied. Twenty five species of corals are reported for the time first from the Hungarian Cretaceous. Fossils derived from the carbonate platform are often found together with those of pelagic origin and monomictic volcanoclastics, indicating a special sedimentary environment. Based on this study the following model is proposed for the Early Cretaceous geological history of the Mecsek Mountains: instead of overall uplift and erosion giant basalt volcanoes grew above sea level until the Valanginian, whilst bathyal conditions were preserved between them. The volcanoes were bordered by gravel beaches, then sandy and silty lagoons, and the edge, of submarine slopes were crowned by atoll-type build-ups. Fossils and rocks of different environments were transported down the slopes of the volcanoes and mixed. As a result of widespread erosion during the Late Cretaceous or Palaeogene only the basal parts of a few volcanoes are preserved.

KEY WORDS: Early Cretaceous; Mecsek Mountains; Hungary; megafossils; microfossils; corals; palaeoecology; basaltic volcanism; slope sedimentation; palaeoenvironment.

1. Introduction

In the central part of the Eastern Mecsek Mountains volcanic and sedimentary formations of mainly volcanoclastic origin form part of a synclinal structure with internal anticlines and imbrications or even nappes (Figure 1). Here the rudist-bearing beds intercalated into the Magyaregregy Conglomerate Formation (Figure 2) were discovered by Hofmann at the turn of the century (Vadász, 1912). Hofmann collected an unusually rich fossil assemblage from the "tuffs and breccia-conglomerate beds of augite-porphyrites" (Vadász, 1912, p. 689) from outcrops at Kisújbánya, Márévár and Jánosi-puszta (or Mecsekjánosi, Figure 3). Hofmann identified 30 bivalve taxa from here (Hofmann & Vadász, 1912–13). Rudist bivalves include: *Valletia germani* (Pictet & Campiche), *Heterodiceras semistriatum* (Hofmann), *Monopleura urgonensis* Matheron, *M. boeckhi* Hofmann, *Bicornucopina petersi* Hofmann, *Toucasia* and *Megadiceras hofmanni* Czabalay (Hofmann & Vadász, 1912–13; Noszky, 1948; Czabalay, 1971).

In addition to bivalves, foraminifera, sponges, corals, crinoids, brachiopods, gastropods, ammonites and belemnites are all known to occur. On the basis of this fauna, Vadász (1912, 1935) suggested a shallow-marine, even beach, origin. Corals were described by Kolosváry (1954). After Vadász (1935), who listed 10 ammonite and belemnite taxa, Horváth (1968) worked on the fossil assemblages from these localities and reported an ammonite assemblage (*Neocomites neocomiensis* (d'Orbigny), *Lithoceras regale* Bean, *Holcostephanus* (*Astieria*) sp., *Acanthoceras hystrichoides* Uhlig, *A.* cf. *hoheneggeri* Uhlig) characteristic for the Upper Valanginian from the variegated tuffaceous beds of the Kisújbánya section.

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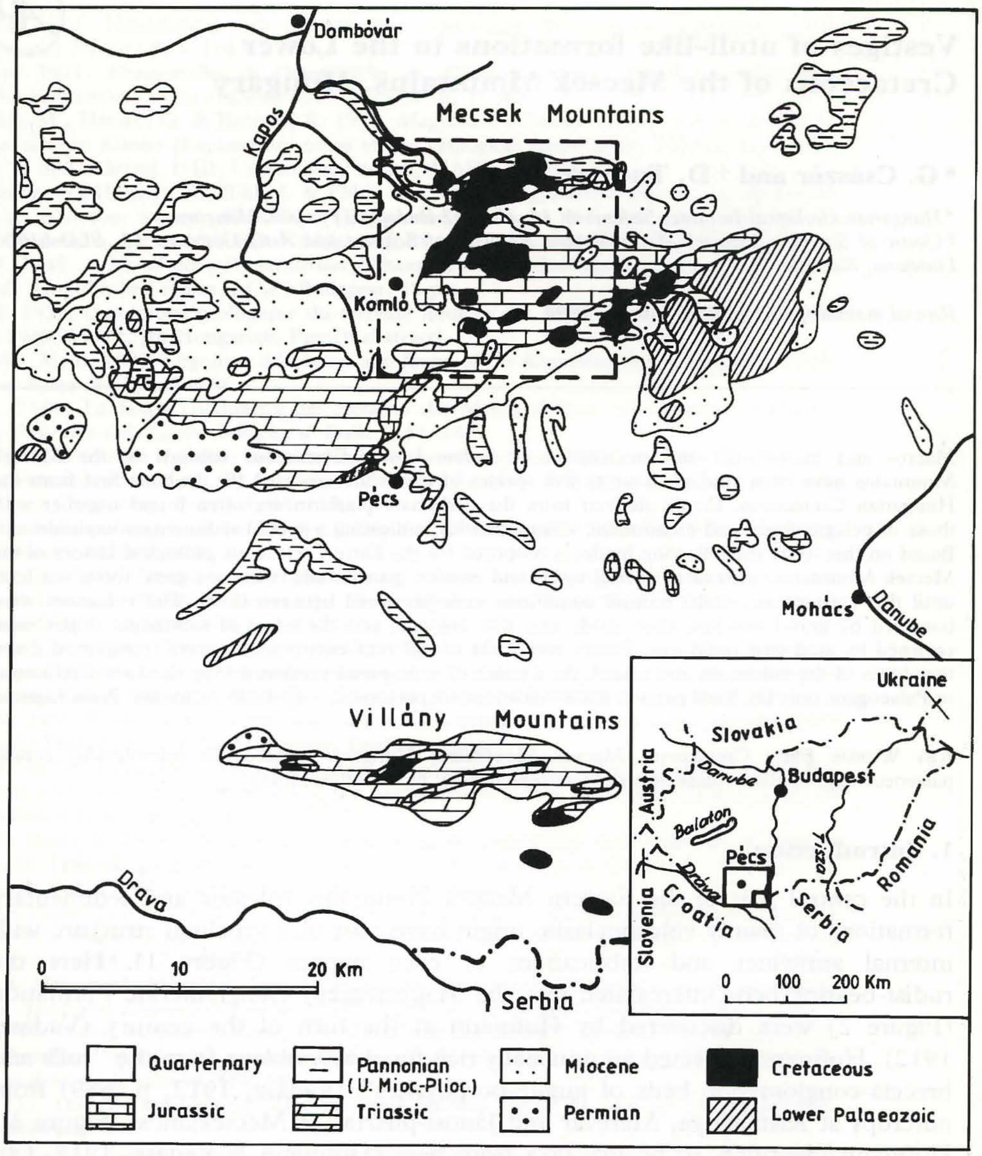

Figure 1. Geology of the Eastern Mecsek. For location of sections studied within area delineated by dashed line, see Figure 3.

The 30 to 40-cm-thick breccia and conglomerate bed intercalated into the ammonitic marl has a rich and varied fossil content (calcareous algae, sponges, hydrozoans, corals, bivalves, gastropods and echinoderms) different from both the underlying and overlying beds. On the basis of this, following Vadász's ideas, Horváth (1968, p. 243) concluded that "in this pile of debris, in addition to elements from the littoral zone there are also representatives from shallower parts of the neritic region. Both in numbers of species and specimens thick-walled bivalves and gastropods predominate". Ammonites were considered to be "redeposited elements of the Valanginian beds". Horváth further stated that fossils of the sandstone beds below the conglomerate resemble those found in the conglomerate bank of the Kisújbánya section.

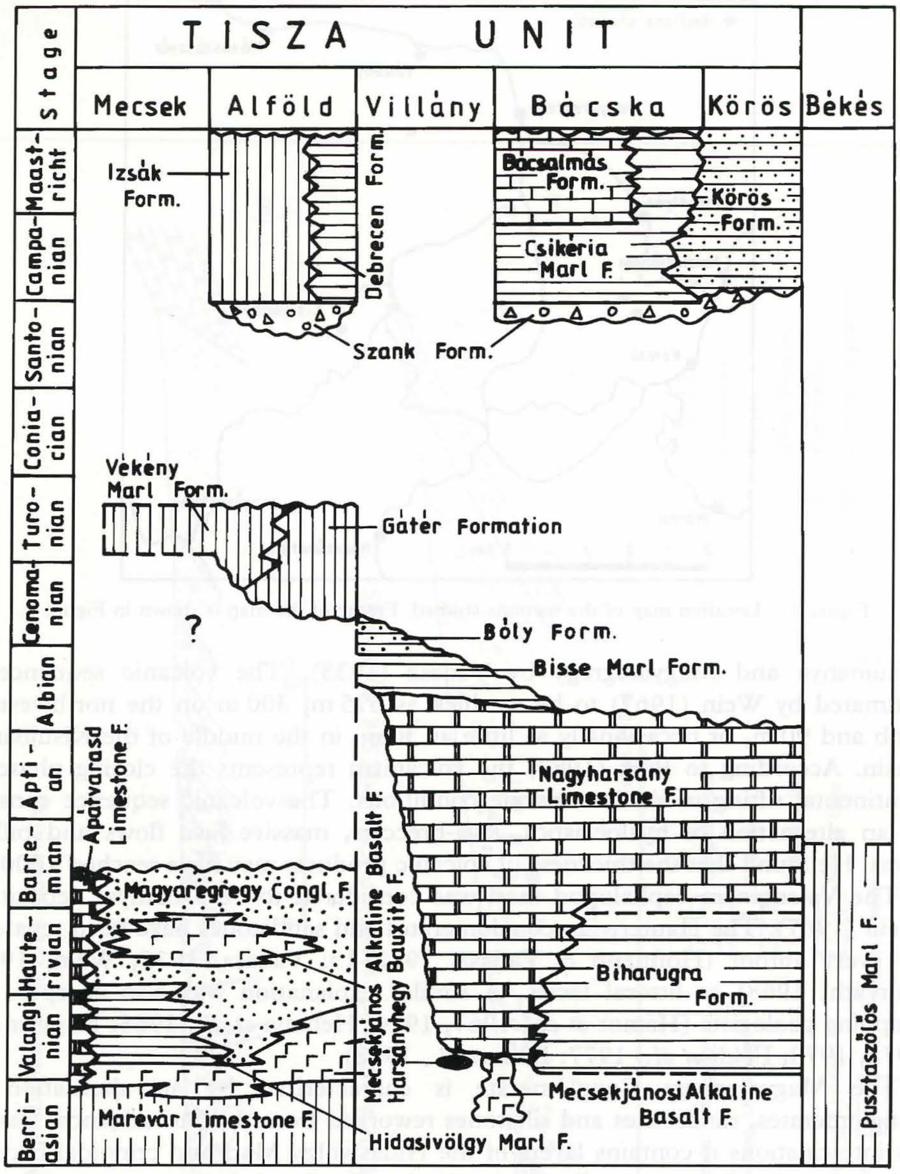

Figure 2. Basic Cretaceous lithostratigraphic units of the Tisza unit.

The Early Cretaceous history of the Mecsek Mountains was summarized first by Horváth (1968). At the end of the Valanginian the bottom of the sea started to rise, the grain-size of the sediment increased gradually, and then the sea was replaced by the land. Ammonites found in the "transgressive conglomerate" gave her the "impression of strange elements within the fossil assemblage" (Horváth, 1968, p. 245). Volcanism of the Mecsekjánosi Basalt Formation started in this area with lava and continued with tuff (Vadász, 1935; Wein, 1967). The volcanic products reached the surface along longitudinal fissures (Hofmann, in Vadász, 1935). According to Bilik (1974, 1983) they comprise Berriasian to Valanginian and Hauterivian phases. A volcanic centre was discovered at Magyaregregy by Wein (in Forgó *et al.*, 1966; Wein, 1967) and Mauritz (1913), and between

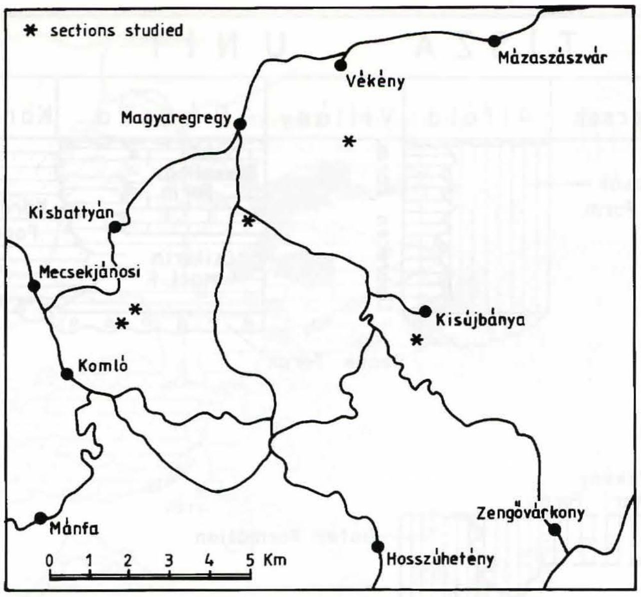

Figure 3. Location map of the sections studied. Frame of the map is shown in Figure 1.

Kisújbánya and Magyaregregy by Vadász (1935). The volcanic sequence is estimated by Wein (1967) to be as thick as 675 m; 300 m on the northwestern limb and 90 m, or occasionally as little as 30 m, in the middle of the Kisújbánya Basin. According to Bilik (1983) the volcanism represents the closing phase of continental rifting in shallow-marine conditions. The volcanic sequence consists of an alternation of hyaloclastics, lava-breccias, massive lava flows and pillow lavas. He found that the thickness of volcanic products may have reached 1000 m.

The Valanginian cephalopod marl was considered to be a bathyal deposit by Wein (1967). The Hauterivian conglomerates and sandstones have been regarded by every author (Hofmann & Vadász, 1912–13; Vadász, 1935; Wein, 1967; Horváth, 1968) as littoral facies. A similar explanation was also accepted by mapping geologists (Hámor *et al.*, 1967, 1974; Hetényi *et al.*, 1968; Nagy *et al.*, 1973, 1978; Földi *et al.*, 1977; Bilik *et al.*, 1978).

The Magyaregregy Conglomerate is characterized by an alternation of conglomerates, sandstones and siltstones reworked from the Mecsekjánosi Basalt. As intercalations it contains layers of the Hidasivölgy Marl and crinoidal beds of the Apátvarasd Limestone. Rudists and other fossils of shallow-water origin are concentrated in the lower third of the Magyaregregy Formation, sometimes in rock-forming quantity.

2. Sections studied

2.1. *Kisújbánya*

Shallow-marine fossils are found in two outcrops at the bottom and in the cut of a cart-track between Pusztaszentlászló and Kisújbánya. Here the Márévár Limestone Formation of Tithonian-Berriasian age underlies the Lower Cretaceous volcanoclastic sequence (Figure 4). It has a tectonic contact with basaltic hyaloclastite of the Mecsekjánosi Basalt. The ammonite-bearing Hidasivölgy Marl grades upwards from the hyaloclastite. It is followed by a 40-cm-thick breccia-conglomerate layer, that is overlain by a soft pelitic sandstone body with

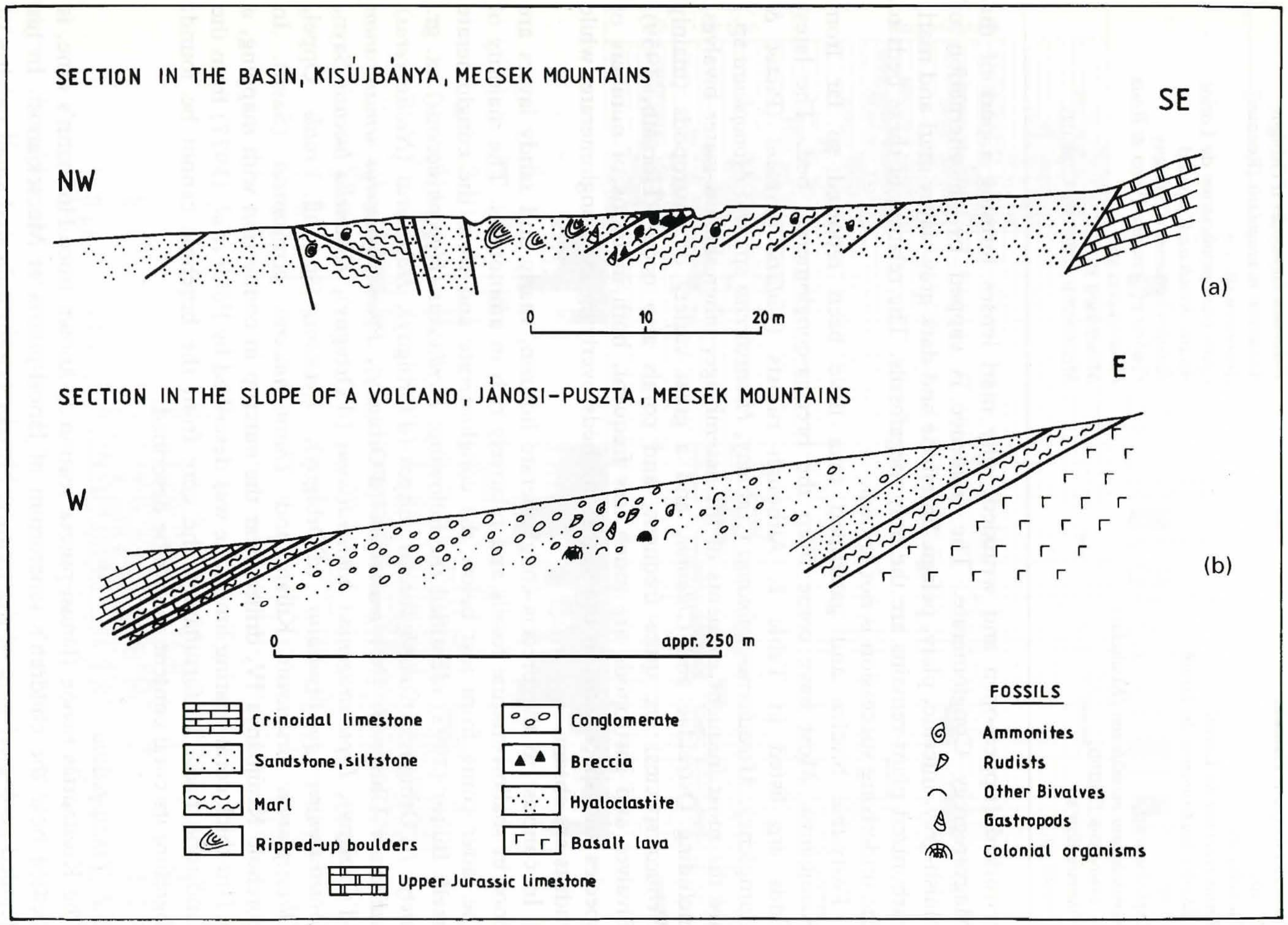

Figure 4. Geological sections at (a) Kisújbánya and (b) Jánosi-puszta.

Table 1. List of new bivalve and gastropod records at Kisújbánya, Mecsek Mountains (Czabalay, 1991)

Nerinea zumoffeni Delpy	*Nerita* sp.
N. sp.	*Neritopsis* sp.
Nerinella lomparti Calzada	*Tylostoma bulimoides* d'Orbigny
N. sp.	*Arcostreon rectangularis* (Roemer)
Eucyclus sp.	*Aetostreon* sp.
Tethis renevieri de Loriol	*Ctenostreon probiscideum* de Loriol
Chlamys landeronensis de Loriol	*Astarte dimidiata* Coquand
C. sp.	*Panopea carteroni* d'Orbigny
Diplodonta sp.	*Fimbria* cf. *gaultina* Pictet & Roux
Semisolarium moniliferum (Michelin)	*Heterodiceras* sp.
S. conoideum (Fitton)	*Monopleura* sp.
Nummocalcar sp.	*Megadiceras hofmanni* Czabalay
Gyrodes sp.	

reworked (ripped-open and wrinkled) silty marl lenses forming a part of the Magyaregregy Conglomerate. The sequence is capped by an alternation of bluish-grey, micritic, platy, pelagic limestone and dark grey clayey marl and marl; carbonized plant remains are the only megafossils. The relation of these beds to the underlying succession is not known.

Forty-five bivalve and gastropod taxa have been reported so far from Kisújbánya. Most have come from the breccia-conglomerate bed. The latest finds are listed in Table 1. Although rudists (*Valletia germani* (Pictet & Campiche), *Megadiceras hofmanni* Czabalay, *Heterodiceras* sp. and *Monopleura* sp.) are the most frequent elements of the assemblage, other shallow-water bivalves, including Ostreidae and *Chlamys*, and a great variety of gastropods (mainly *Nerinea* species) are quite frequent, and corals also occur (Horváth, 1959). Bivalves and gastropods are much less frequent, both in terms of numbers of species and specimens, in the sandstone beds overlying the conglomerate, while rudists are absent.

In contrast to the breccia-conglomerate horizon, marly and sandy layers are poor in shallow-marine fossils and relatively rich in ammonites. The majority of the latter come from just below the conglomerate and from the conglomerate itself. Bujtor (1993) identified the following: *Phylloceras (Hypophylloceras)* ex. gr. *thetys* (d'Orbigny), *Calliphylloceras calypso* (d'Orbigny), *Haploceras (Neolissoceras) salinarum* Uhlig, *H.* (*N.*) *grasianum* (d'Orbigny), *Ptychophylloceras semisulcatum* (d'Orbigny), *Leptotetragonites honnoratianus* (d'Orbigny), *Kilianella lucensis* Sayn, *Protetragonites quadrisulcatus* (d'Orbigny), *Lytoceras* sp. aff. *sutile* Oppel, *Olcostephanus drumensis* Kilian and *Thurmanniceras pertransiens* (Sayn). In borehole Kisújbánya IV, drilled near the outcrop in connection with mapping, a 1.1-m-thick coral-bearing limestone was described by Földi *et al.* (1977) from the sandstone beds. Unfortunately, the core from the borehole cannot be found; therefore its coral content cannot be described.

2.2. Jánosi-puszta

The Korhadtfás ravine (Jánosi-puszta section 1) known since Hofmann's time, is located near the children's sanatorium of Jánosi-puszta at Mecsekjánosi. In his detailed geological map of the vicinity, Noszky (1948) indicated small patches of echinoderm-bearing limestone underlain by Lower Cretaceous volcanite in the valley. In thin-sections of the limestone above he found a rich assemblage of foraminifera, radiolarians, bivalves and brachiopods.

Here the Mecsekjánosi Basalt is overlain by a relatively thick unit of the

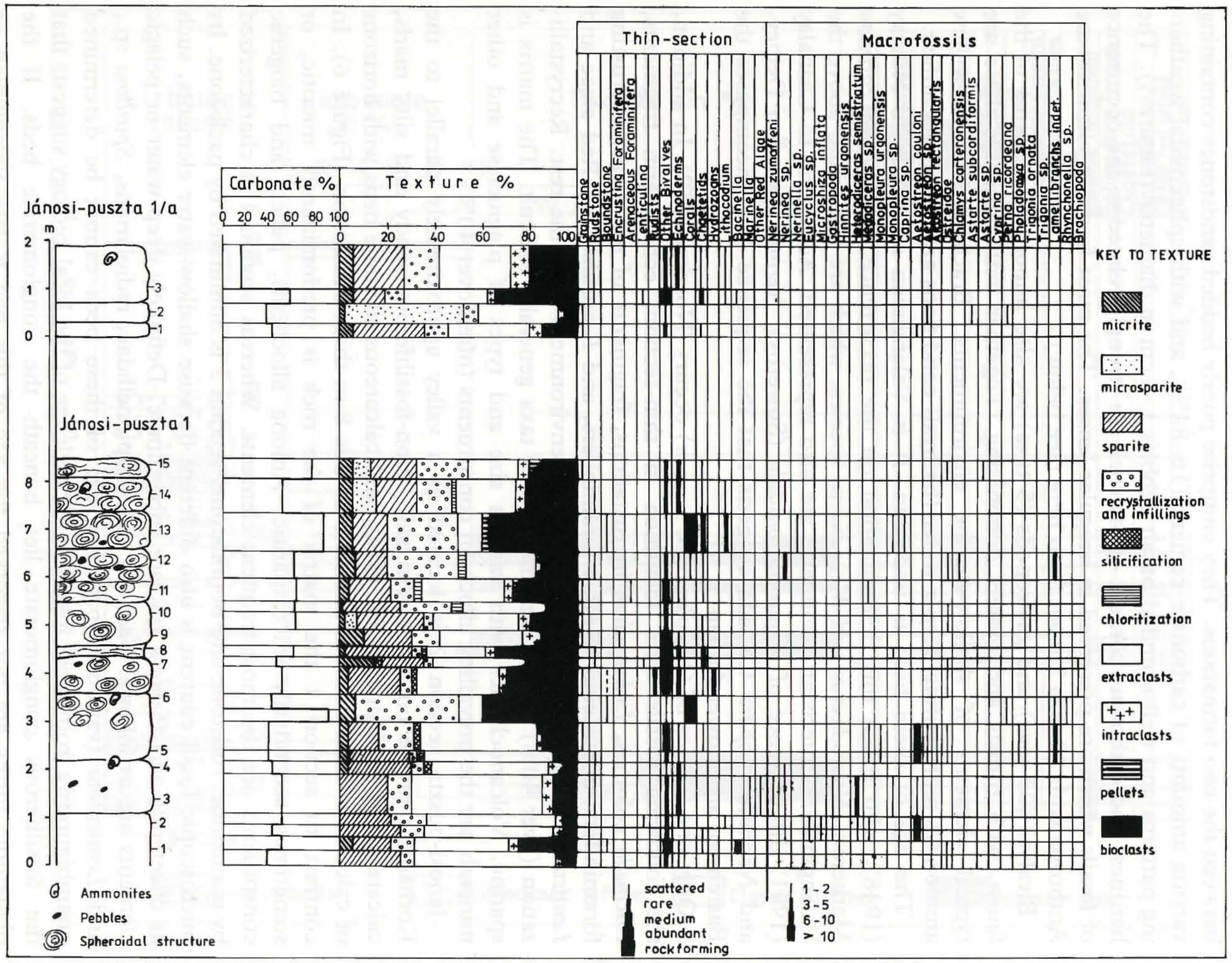

Figure 5. Columnar section of Jánosi-puszta 1 and Jánosi-puszta 1/a, and results of investigations.

Hidasivölgy Marl Formation (Figure 4) from which Horváth (1959) identified *Neocomites neocomiensis* (d'Orbigny). The formation is overlain by the Magyaregregy Conglomerate which is characterized by an alternation of sandstone and conglomerate beds whose clasts correspond to the underlying volcanics. Fossiliferous beds are found approximately 30 m above the obscured contact between the two formations. They comprise poorly bedded sandstones containing varying amounts of carbonate cement (16–84%), and with sphaeroidal weathering patterns and well-rounded basalt pebbles 1–5 cm in diameter (Figure 5). The hardness and carbonate content of the rock are strongly related to the occurrence of fossils which are preserved in irregular lenses. The most frequent elements are Anthozoa with 28 taxa known from here (see below).

Bivalves (23 taxa) and gastropods (5 taxa) are also important elements of the fauna, with rudists and oysters dominating. Together with nerineids these are typical elements of shallow-marine environments. Brachiopods and a few ammonites representing deeper water (bathyal) conditions are not yet identified.

The age of these beds is uncertain. It is Valanginian according to Noszky (1948), who based this determination on the occurrence of *Toucasia carinata* Matheron. *Heterodiceras* and *Megadiceras* species, which are not found above the Valanginian/Hauterivian boundary, are also represented. According to Czabalay (1991) the presence of *Requienia lonsdalii* (Sowerby), *Nerinea zumoffeni* Delpey, and *Nerinella lomparti* Calzada suggests that the sequence also encompases the Barremian and Lower Aptian.

Only one species of *Orbitolina* (*O. scutum*) occurs (Noszky, 1952). In addition, the following fossils were identified in thin-section: echinoderm fragments, *Bacinella* colonies, *Lithocodium* incrustations, fragments of red algae, encrusting foraminifers, arenaceous benthic foraminifers, and *Lenticulina* sp. Red algae and *Lenticulina* indicate a significantly deeper environment than the rest. Recrystallization (over 40%) makes identification of taxa generally difficult. The matrix is sparitic. Volcanoclastics with various size and types of plagioclase and other minerals are the prevailing allochem constituents (often over 40%).

Jánosi-puszta section 2 is located in a valley approximately parallel to the Korhadtfás ravine on its eastern side. Non-fossiliferous sandy and silty marls, calcareous marls with rare lithoclasts, and calcareous siltstone beds with horizons of calcareous marl nodules alternate in this 8-m-thick succession (Figure 6). In contrast to section 1 the matrix of the rock is predominantly micritic, or sometimes secondarily microsparitic. Among allochems, pellets and biogenic constituents are the most frequent elements. Whereas section 1 is characterized by grainstone, rudstone and boundstone, section 2 is dominated by packstone. Its microscopic fossil content is also different because shallow-water elements, such as chaetetids and *Pieninia* sp., are subordinate. Definitely deep water or pelagic elements are as follows: *Cadosina* sp., Calpionellidae, radiolarians, *Spirillina* sp., and *Lenticulina* (various spp.). The age of these beds cannot be determined unambiguously from these fossils but knowledge of the local geology suggests that the fossiliferous conglomerate lies beneath the conglomerate beds. If the planktonic forms are not reworked the age of this bed is late Valanginian or perhaps early Hauterivian.

2.3. *Márévár valley, Magyaregregy*

At the southern side of the entrance to the valley a sedimentary-volcanogenic Lower Cretaceous sequence crops out for several hundred metres at a locality

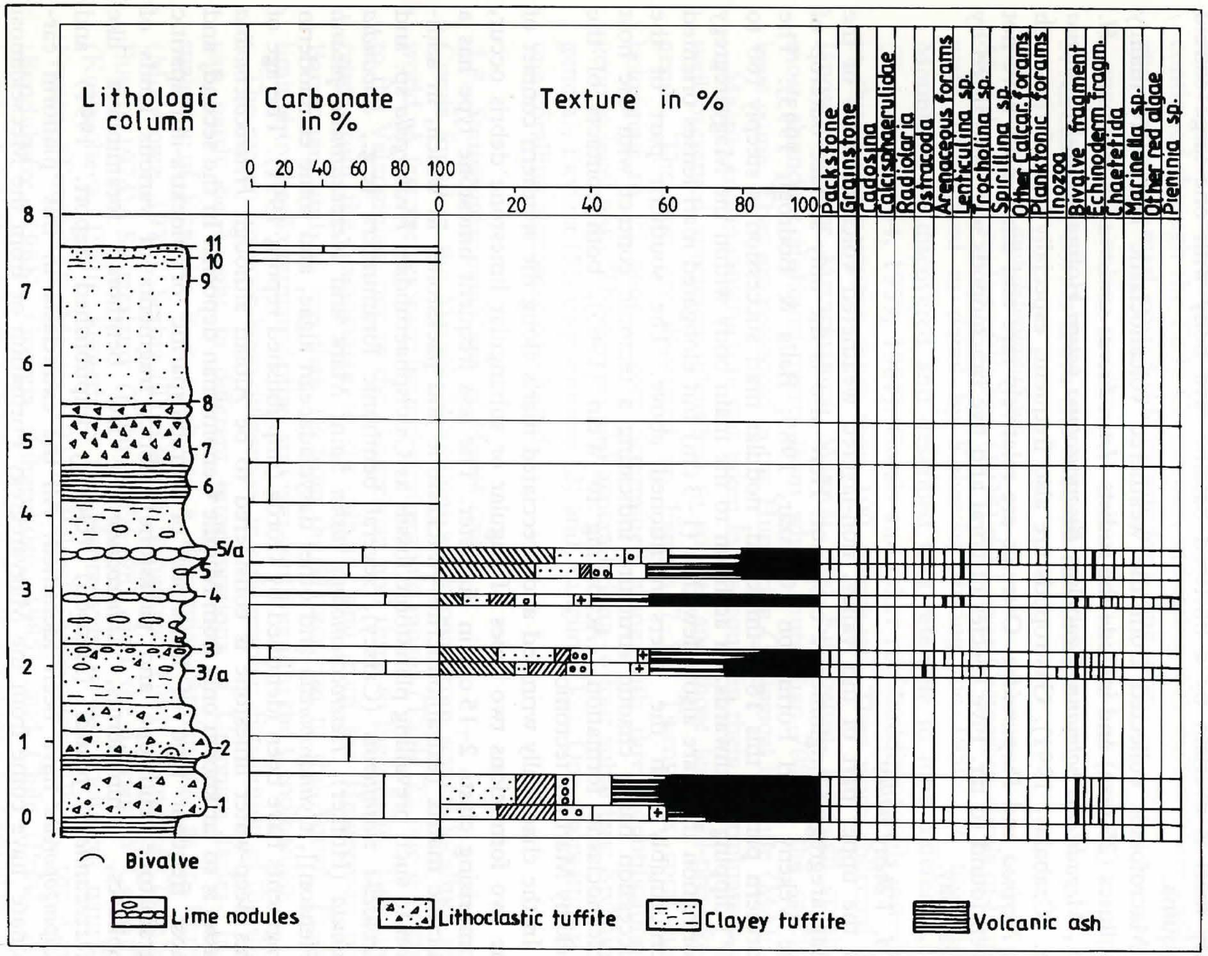

Figure 6. Columnar section of Jánosi-puszta 2 and results of investigations. For key to texture, see Figure 5.

known as Krajcár mill. A profile of this section was published by Horváth (1968). The lower third consists of coarse-grained conglomerates dipping concordant with the valley direction. The first occurrence of macrofossils coincides with a change in lithology, where conglomerates are gradually replaced by weathered volcanoclastics. The frequency of fossils increases up-section, and at the top a silty marl is overlain by a blistered basaltic lava body with one large ostreid coquina.

Macrofossils collected from the weathered volcanoclastic layers are mainly molluscs (25 taxa) and include the rudists *Heterodiceras semistriatum* Hofmann, *H.* sp., *Megadiceras hofmanni* Czabalay, *Bicornucopina petersi* Hofmann, and *Requienia* sp. (Czabalay, 1991). Gastropods are also frequent, especially large forms such as *Nerinea* and *Purpuroidea*. Ostreids are relatively rare and ammonites have not been found so far. Five species of coral and five brachiopods were also listed by Czabalay.

2.4. *Vékény valley*

In the upper part of this valley, non-layered weathered volcanoclastics of the Magyaregregy Conglomerate crop out. Here also is the only surface outcrop of the Vékény Marl Formation (Császár, 1985; Balla & Bodrogi, 1993). The northern part of this 18-m-thick red, nodular marl succession is steeply (60 to 80°) dipping northwards. In addition to the main body within the Magyaregregy Formation there are also a few thin (1–3 cm) but elongated marl lenses oriented conformably with the layers mentioned above. The southern part of the succession has a chaotic structure indicating a tectonic contact with the host volcanoclastic formation. (According to Wein (1965), both contacts of the Vékény Marl are tectonic.)

In the chaotically wrinkled and brecciated marls along the southern contact of the two formations two types of angular or subangular limestone debris occur, comprising clasts 2–15 cm in diameter. The less frequent limestone type has a micritic matrix (extrabiomicrite—wackestone and packstone) in which, in addition to such prevailing planktonic fossils as Calcisphaerulidae, *Hedbergella* sp. and *Favusella washitensis* (Carsey), several benthonic foraminifera [e.g., *Sabaudia minuta* (Hofker), *Heterocoscinolina ruskei* Saint Mark and *Nezzezatinella picardi* (Henson)], *Cylindroporella* and other dasycladacean algae, and some echinoderm fragments have been identified by Görög (unpublished report, 1991). The age of this deep-water limestone is considered to be Albian although *Heterocoscinolina ruskei* is so far known only from Middle Cenomanian deposits. In the second, and most frequent type of limestone of intrabiosparitic or bioextra-intrasparitic (grainstone, rudstone and packstone) fabric, fragments of various kinds of molluscs, echinoderms, *Lithocodium*, a few benthonic foraminifera like *Nezzezatinella picardi* (Henson) (Görög, unpublished report, 1991) and *Salpingoporella* have been identified. All the extraclasts in this 'platform carbonate' have come from the Magyaregregy Formation or from the Mecsekjánosi Basalt directly. From the borehole Vékény VI, situated to the east of the outcrop, a 1-m-thick red marl was reported by Nagy *et al.* (1973) from within a basalt conglomerate and lava breccia. Hámor (oral comm., 1992) found a coral colony 40 cm in diameter in the scree of the valley. This is the first find of a fragment of the Cretaceous build-up within the so-called 'Northern imbrication zone' of the Mecsek Mountains.

The age of the host rock was considered to be Cenomanian by Sidó (1961), who described a rich association of planktonic foraminifera from this outcrop. According to Balla & Bodrogi (1993) the age is early to middle Turonian. Limestone clasts are undoubtedly older than the Vékény Marl. However, the exact age of the biodetrital limestone is not yet known, although it is undoubtedly younger than those found at Kisújbánya and Jánosi-puszta, and in Márévár valley. It can be supposed that volcanic activity akin to that of the Valanginian continued through the Early Cretaceous, indicating that shallow-water carbonate and deep water marl existed side by side for a long time.

3. Cretaceous corals from the Mecsek Mountains

3.1. Collections and determinations

After the initial studies of Vadász (1935) the Lower Cretaceous corals of Hungary were investigated in detail by Kolosváry during the 1950s. In the Mecsek Mountains he discovered and described taxa referable to nine different genera (Kolosváry 1954, 1959, 1961). Corals and other reef-building fossils introduced in this paper comprise more than 100 specimens. They were collected from Jánosi-puszta or Mecsekjánosi, Márévár, and Kisújbánya, although corals are most abundant at Jánosi-puszta from where more than 70% of the specimens have come. They are preserved in the Hungarian Geological Institute (MÁFI).

Macro- and microstructure was taken into account in their determination, with well preserved specimens identified to species and those less well-preserved to genus. The best are illustrated on Figures 7–10. Twenty six coral species belonging to 22 genera were determined along with three identifications to generic level only. The species and genera belong to four suborders: Stylinina (6 genera), Faviina (5), Eupsammina (2) and Fungiina (12). One stromatopore and one coralline alga were also found.

3.2. Stratigraphic significance of Mecsek corals

Corals found in the Mecsek Mountains are known from several localities in the world. A few species have limited stratigraphic ranges (Table 2): one is restricted to the Valanginian, one to the Hauterivian and three to the Albian. Two species range from the Valanginian to the Albian, one from the Hauterivian to the Barremian, and no less than 12 from the Hauterivian to the Aptian. Four are limited to the Barremian-Aptian and two continue into the Cenomanian.

The reason for such large differences in stratigraphic distribution of the species can partly be sought in different interpretations of Urgonian facies. In the majority of localities it is attributed a Barremian–Aptian age as in Romania (Morycowa, 1971), Serbia (Turnšek & Mihailovič, 1981), Slovenia (Turnšek & Buser, 1974), Switzerland (Koby, 1896–98), and the Ukrainian Carpathians (Kusmicheva, 1980). Sometimes the Hauterivian is also included: namely in France (Turnšek & Masse, 1973), Poland (Morycowa, 1964), the Crimea (Bendukidze, 1961), Georgia (Siharulidze, 1985), and Chile (Prinz, 1991). Corals of Albian age have so far been found only in Georgia (Siharulidze, 1979), Madagascar (Alloiteau, 1958), Kyzylkum (Kusmicheva & Pyanovskaya, 1970) and a few other places. The Cenomanian age of two species was established in Germany (Löser, 1989) and Italy (Prever, 1909).

The Urgonian reef facies in Hungary embraces almost the entire Lower Cretaceous (Császár & Haas, 1984). Recent investigations in the Pyrenees have also established several reefal episodes in the Early Cretaceous, where the

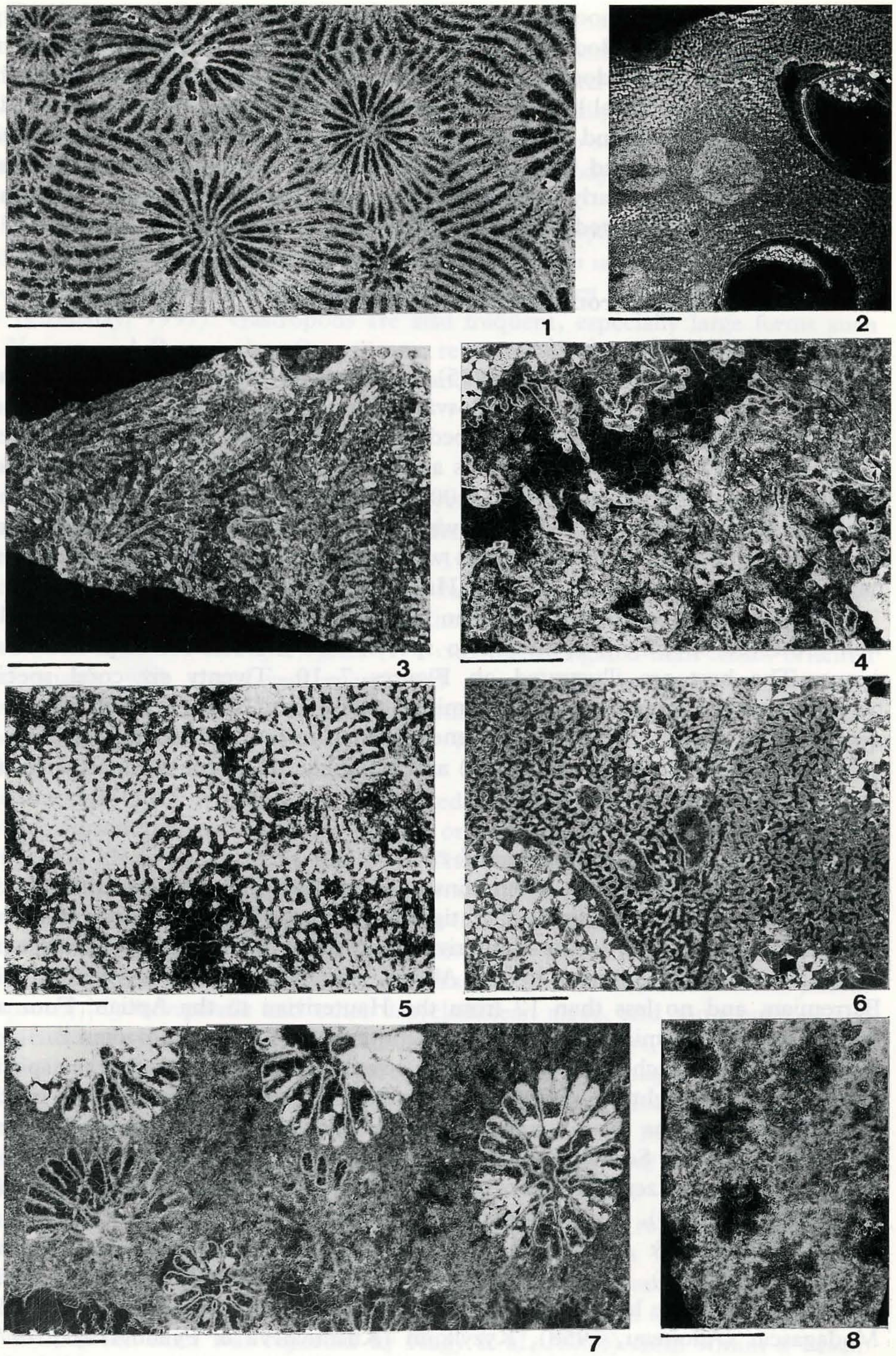

Figure 7. Negative micrographs of massive plocoid (1, 4, 6–8), confluent (2, 5) and meandroid (3) coral colonies from transverse thin-sections, Jánosi-puszta (Jp), Márévár (Ma) and Kisújbánya (Ki), Mecsek Mountains. (1) *Diplocoenia decaseptata* Kusmicheva 1966, Jp/1-9a; (2) *Microsolena guttata* Koby 1898, Jp 505/7-23; (3) *Microphyllia* cf. *undans* (Koby, 1885), Jp/1-10a; (4) *Paretallonia bendukidzae* Siharulidze 1972, Jp 505/8-1; (5) *Synastraea bellula* d'Orbigny 1850, Jp/2-2a; (6) *Actinaraea tenuis* Morycowa 1971, Jp 505/6-5; (7) *Columnocoenia ksiazkiewiczi* Morycowa 1964, Ki/K-6411; (8) *Adelocoenia biedai* Morycowa 1964, Jp/K-13736. Scale bar = 3 mm.

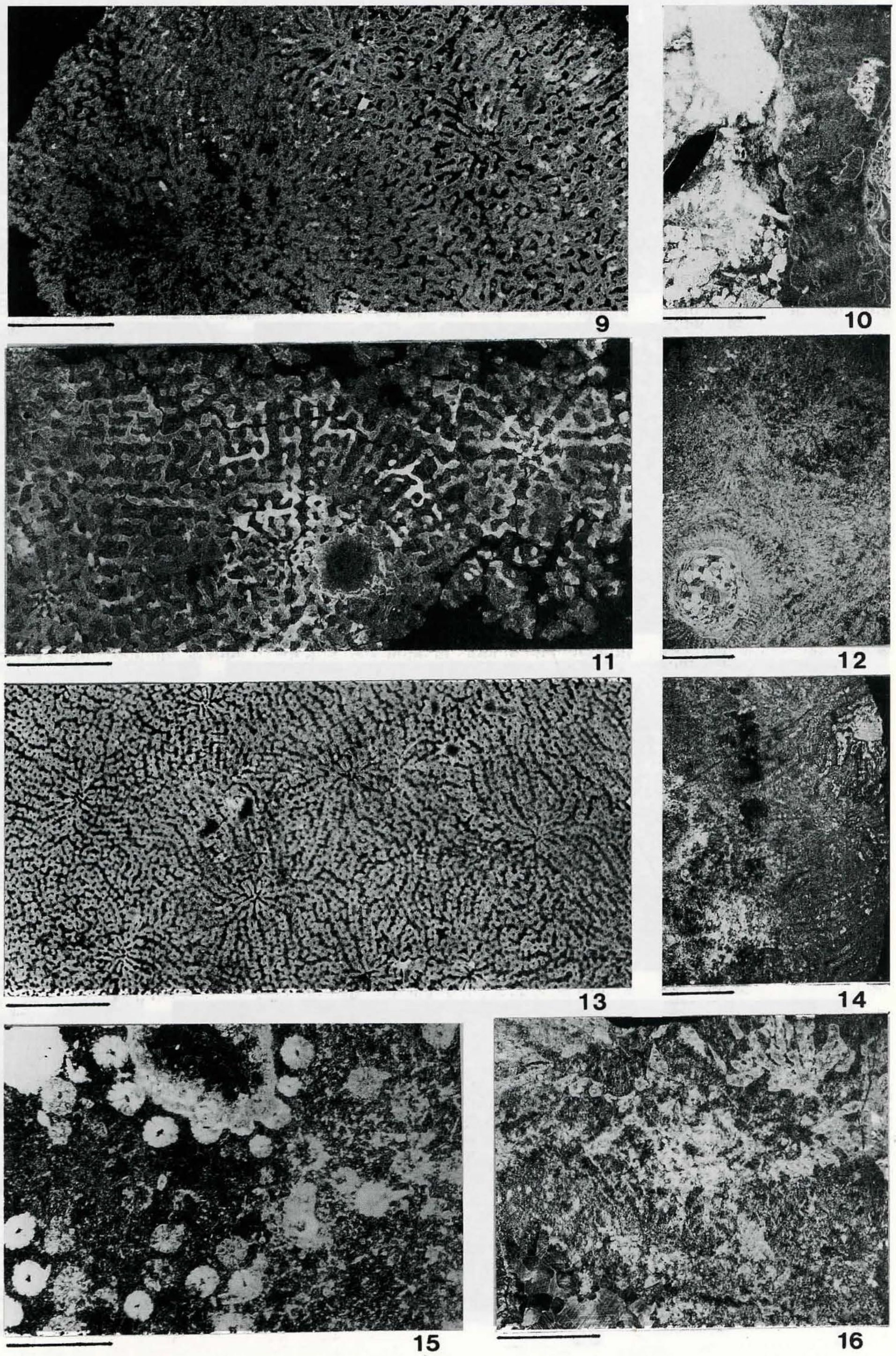

Figure 8. Negative micrographs of massive, confluent (9, 11, 13, 14, 16), meandroid (10), and plocoid (12, 15) coral colonies from transverse thin-sections, Jánosipuszta (Jp) and Márévár (Ma), Mecsek Mountains. (9) *Dimorpharaea barcenai* (Felix 1891), Ma/1-4a; (10) *Eugyra pussila* Koby 1895, Jp 505/9-11; (11) *Microsolena distefanoi* Prever 1909, Jp/505/ 9-3; (12) *Polyphylloseris convexa* Fromentel 1857, Jp 505/6-1b; (13) *Microsolena exigua* Koby 1887, Ma/1-3a; (14) *Siderofungia irregularis* Felix 1891, Jp 505/9-7; (15) *Stylina parvistella* Volz 1903, Jp/2-1b; (16) *Thamnasteria meandra* (Koby 1898), Jp/1-5a. Scale bar = 3 mm.

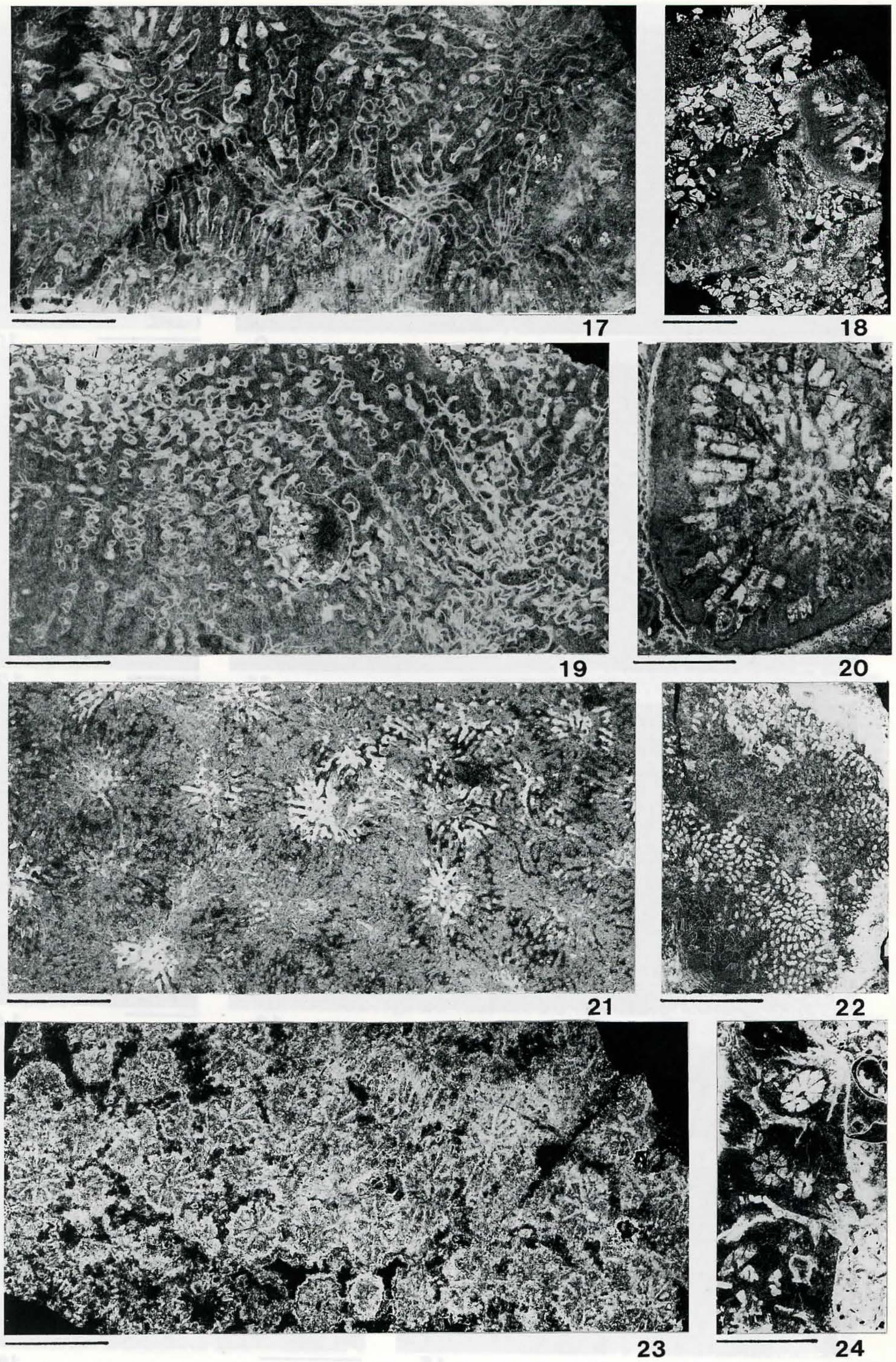

Figure 9. Negative micrographs of massive confluent (17, 19, 21), massive plocoid (22, 23), branching dendroid (24), branching phaceloid coral colonies (18), and solitary ceratoid corallum (20), from transverse thin-sections, Jánosi-puszta (Jp) and Márévár (Ma), Mecsek Mountains. (17) *Thamnasteria sinuosa* Morycowa 1964, Jp 505/ 7-13; (18) *Placophyllia curvata* Turnšek 1974, Jp 505/8-4; (19) *Microsolenastraea balcanica* Turnšek 1981, Jp/1-3a (transverse-oblique section); (20) *Palaeopsammia zljebinensis* Turnšek 1981, Jp 505/8-8; (21) *Thamnaraea mammelolata* Turnšek 1981, Ma/1-2; (22) *Mesomorpha ornata* Morycowa 1971, Jp 505/8-1; (23) *Heliocoenia rarauensis* Morycowa 1971, Jp/K 13740; (24) *Enallhelia* sp., Jp/1-4. Scale bar = 3 mm.

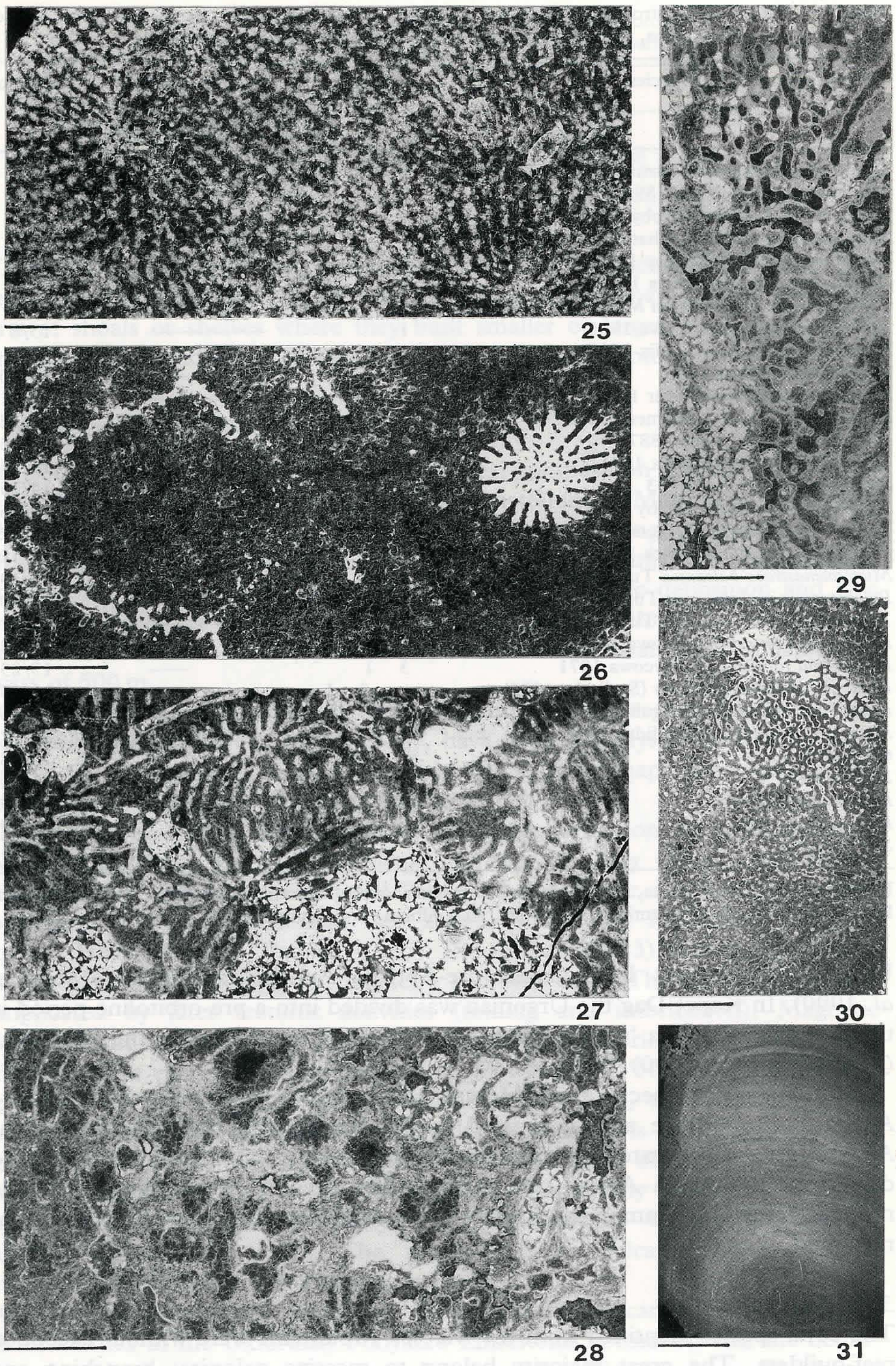

Figure 10. Negative micrographs of coral (25–29), stromatoporoid (30) and algae (31) colonies from transverse thin-sections, Jánosi-puszta (Jp), Mecsekjánosi (MJ), Márévár (Ma) and Kisújbánya (Ki), Mecsek Mountains. (25) *Dimorphastraeopsis patellaris* (Stoliczka 1873), massive confluent concentric colony, Ma/b; (26) *Latiastraea mucronata* Siharulidze 1979, massive meandroid-ceratoid colony, Jp/2-3; (27) *Myriophyllia propria* Siharulidze 1979, massive meandroid colony, MJ/1-9; (28) *Confusaforma* sp., transverse-oblique section of massive plocoid colony, Jp 505/7-15; (29) *Epistreptophyllum* sp., solitary cylindrical corallum, Jp 505/8-11; (30) *Dehornella* sp., Jp/1-1a; (31) *Solenopora* sp., longitudinal section, Ki/c. Scale bar = 3 mm.

Table 2. List of corals, stromatoporoids and coralline algae in the Lower Cretaceous of the Mecsek Mountains, with global stratigraphic distribution of the coral species

Species	Mecsek			Strat. distrib.						Fig/No.
	J	M	K	V	H	B	A	Al	C	
Diplocoenia decaseptata Kusmicheva 1966	1			—						13/1
Microsolena guttata Koby 1898	2			—	—	—	—			13/2
Microphyllia cf. *undans* (Koby 1885)	1			—	—	—	—	—		13/3
Paretallonia bendukidzae Siharulidze 1972	1				—					13/4
Synastraea bellula d'Orbigny 1850	3				—	—				13/5
Actinaraea tenuis Morycowa 1971	5				—	—	—			13/6
Columnocoenia ksiazkiewiczi Morycowa 1964	3		1		—	—	—			13/7
Adelocoenia biedai Morycowa 1964	1				—	—	—			13/8
Dimorpharaea barcenai (Felix 1891)	1	2			—	—	—			14/9
Eugyra pussila Koby 1898	1				—	—	—			14/10
Microsolena distefanoi Prever 1909	2				—	—	—		—	14/11
Polyphylloseris convexa Fromentel 1857	1				—	—	—			14/12
Microsolena exigua Koby 1887	8	2			—	—	—			14/13
Siderofungia irregularis Felix 1891	1				—	—	—			14/14
Stylina parvistella Volz 1903	12				—	—	—			14/15
Thamnasteria meandra (Koby 1898)	2				—	—	—			14/16
Thamnasteria sinuosa Morycowa 1964	6				—	—	—			15/17
Placophyllia curvata Turnšek 1974	1					—	—			15/18
Microsolenastraea balcanica Turnšek 1981	2					—	—			15/19
Palaeopsammia zljebinensis Turnšek 1981	2					—	—			15/20
Thamnaraea mammelonata Turnšek 1981		1				—	—			15/21
Mesomorpha ornata Morycowa 1971	1						—		—	15/22
Heliocoenia rarauensis Morycowa 1971	3	1					—			15/23
Dimorphastraeopsis patellaris (Stoliczka 1873)		3	1					—		16/25
Latiastraea mucronata Siharulidze 1979	1							—		16/26
Myriophyllia propria Siharulidze 1979	1							—		16/27
Confusiforma sp.	3									16/28
Enallhelia sp.	1									15/24
Epistreptophyllum sp.	2									16/29
Dehornella sp.	1									16/30
Solenopora sp.			1							16/31

Localities: J = Jánosi-puszta, M = Márévár, K = Kisújbánya. Chronostratigraphy: V = Valanginian, H = Hauterivian, B = Barremian, A = Aptian, Al = Albian, C = Cenomanian.

Urgonian facies has been dated pre-Aptian, Aptian and Albian (Scott *et al.*,1990). In Kopet Dag the Urgonian was divided into a pre-orbitoline period in the Hauterivian and a 'mature' period with various reef faunas in the Barremian (Preobrazhensky, 1990).

The majority of species from Mecsek Mountains belong to the Hauterivian–Aptian period. Some already existed in the Valanginian or survived into the Albian. The widest extent of coral reef fauna accompanied by orbitolines lived during the Barremian–Aptian time interval. The ages of the corals recovered do not match those of ammonites, in spite of the fact that ammonites seem not to be reworked.

3.3. Palaeoecology

The coral species identified from the Mecsek Mountains were without exception reef-builders. The great majority belong to massive colonies; branching and solitary forms are in the minority (Table 3). In manner of growth they are mainly encrusting and bulbous. This means that they lived in very shallow water and grew laterally instead of upwards. Fragments and rounded pieces of colonies imply resedimentation. In principle this could have happened several times.

Table 3. Occurrence of coral species and genera according to their form in the Lower Cretaceous of the Mecsek Mountains

Massive		Branching		Solitary	
confluent	11	phaceloid	1	ceratoid	1
plocoid	10	dendroid	1	cylindrical	1
meandroid	4				

The complete lack of Amphiastraeids, which are characteristic of front reef areas, shows that the corals in the Mecsek Mountains prospered in the protected parts of shoals or shelves where they built smaller or larger patch reefs, or in some places only individual monolithic families of coral colonies.

4. Interpretation of volcanic activity

The petrographical, mineralogical and chemical composition and the appearance of the volcanic products are varied, as demonstrated by Mauritz (1913), Bilik (1974, 1983) and Kubovics & Bilik (1984). According to these authors submarine volcanic activity started in the Berriasian, mainly with hyaloclastite products. There then followed several cycles of pyroclastic deposition and lava flows. Two cycles are proven directly and one indirectly. Pillow lavas are found at the start of lava flows and imply water depths in the Berriasian–Valanginian sea in excess of 500 m.

Geomagnetic measurements, carried out around Magyaregregy between 1954 and 1964 (Molnár, 1962, 1963, 1964), have been reanalysed by Kovácsvölgyi (Figure 11—unpublished map). The anomalies in these maps are isometric that indicate single rather than splitting volcanoes.

Differential erosion of the Cretaceous and older formations to form anticlines and synclines make the location, shape and size of Early Cretaceous volcanic build-ups very difficult to estimate. The thickness of the Mecsekjánosi Basalt Formation is similarly uncertain (see above) because of subsequent irregular erosion. Hofmann's (in Vadász, 1935) and Bilik's (1983) theory of splitting volcanoes is not supported by magnetic anomaly data. The picture is further complicated by later tectonic activities (folding and imbrication). Magnetic anomalies and probably the volcanoes themselves are oriented in a NE–SW direction in the vicinity of Magyaregregy, E–W within the 'Northern imbrication' area, and ENE–WSW in the 'Southern imbrication' area, which are possibly a result of folding and substantial but regular erosion. It is very likely that the density of volcanoes was high within the Mecsek zone of thinned crust and decreased in the direction of the thick crust. This is why only the occasional smaller volcano occurs in the Villány zone (Nagybaracska—Császár *et al.*, 1981; Babarcszöllős—Fülöp, 1966). The distribution of volcanic material in a north–south oriented profile is shown in Figure 12.

Opinions vary as to the onset and duration of the volcanic activity. Angular volcanoclastics in the Oxfordian Fonyászó Limestone Formation and the bentonitic clays in between the limestone layers of the Kimmeridgian Kisújbánya Limestone Formation can be considered as forerunners of the Berriasian volcanic activity. K/Ar dating of basinites and alkaline basalts of the Mecsek Mountains (Harangi & Árva-Sós, 1993) give ages of between 108.0 ± 4.1 and 134.6 ± 5.1 Ma with an average of 123.2 ± 5.1 Ma. However, it is well known that

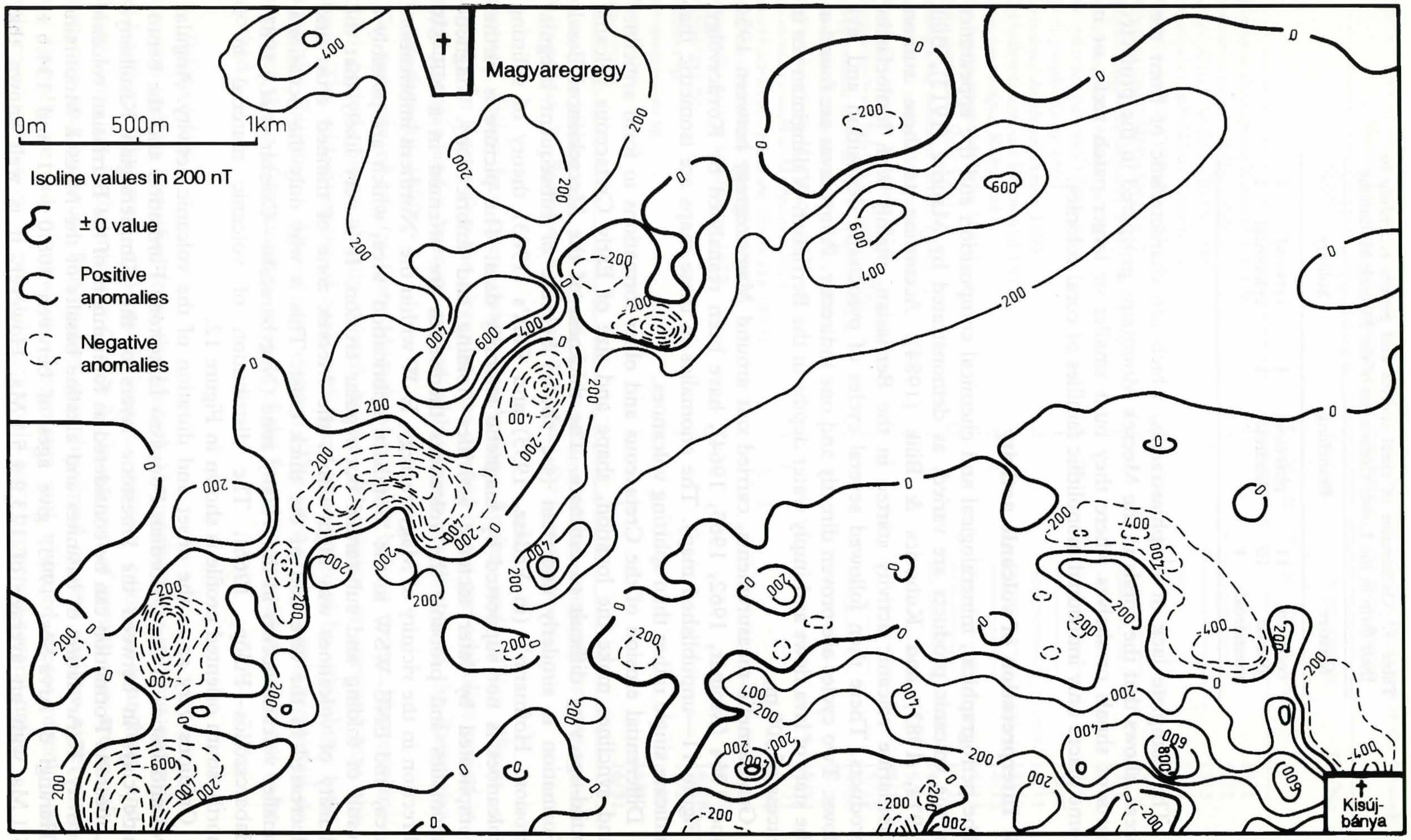

Figure 11. Magnetic ΔZ anomaly of the Magyaregregy vicinity (mapped by Molnár, 1962; re-analysed by Kovácsvölgyi during 1992, unpublished).

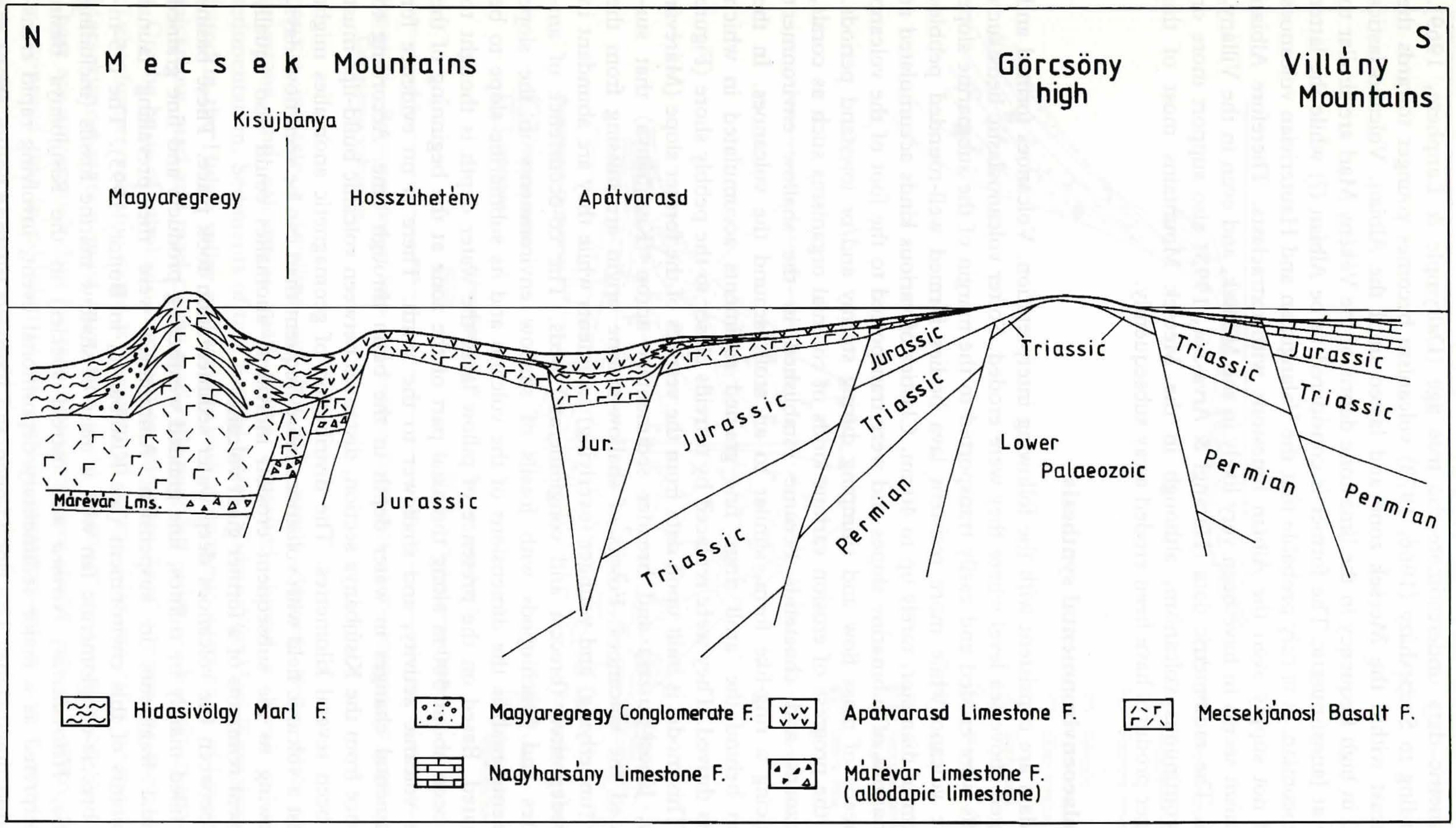

Figure 12. Conceptual profile oriented N–S through Eastern Mecsek in the Early Cretaceous.

radiometric data underestimate the true age (Dalrymple & Lanphere, 1969). According to Szepesházy (1966, 1973) volcanism becomes younger towards the northeast within the Mecsek zone and lasted until the Albian. Volcanoclastics found in high frequency in the limestone debris of the Vékény Marl are similar to those at Jánosi-puszta. The former is considered to be Albian (?) while the latter is Neocomian. It is very probable that the Valanginian and Hauterivian volcanoes could not supply even the Albian limestone with extraclasts. Therefore Albian volcanism seems to have been very likely in the Mecsek, and even in the Villány, zones. The radiometric data (Harangi & Árva-Sós, 1993) also support more or less continuous volcanism, although in the Mecsek Mountains most of the younger products have been eroded away subsequently.

5. Palaeoenvironmental synthesis

Our data are consistent with the following interpretation. Volcanoes formed and emerged above sea level where they were eroded. Softer volcanoclastic beds such as tuffs were eroded and easily transported to the margin of the submarine slope of the volcano while more resistent lava bodies formed well-rounded pebbles 2–5 cm in diameter, rarely up to 40 cm. Clastics of various kinds accumulated at the margins of submarine slopes and were transported to the foot of the volcano by means of mass flow and slumping during stormy and/or lowstand periods. With the progress of erosion various kinds of colonial organisms such as corals, hydrozoans and chaetetids became established in the shallow environment producing a ring-like form, similar to an atoll, around the volcanoes. In the lagoon behind the 'atoll rings' fine grained sediments accumulated in which rudists thrived. They were replaced by ostreids closer to the pebbly shore (Figure 13). This model is built upon data from the vestiges of the former slope (Márévár valley, Jánosi-puszta) and broader sedimentary apron (Kisújbánya) that surrounded the volcanoes. Fossils of shallow-marine origin are missing from the older (underlying) and younger (overlying) sediments while they are abundant in the redeposited (breccia and conglomerate) beds. The co-occurrence of ammonites and brachiopods with fossils of shallow environments in the slope sediments enables the dimensions of the volcano and its submarine slope to be estimated. Based on the presence of pillow lavas the water depth is thought to have been about 500 m along the axial part of the zone at the beginning of the major volcanic activity, and shallower to the south. There is no evidence for fundamental changes in water depth in the basin through time. According to evidence from the Kisújbánya section, distances between volcanic build-ups must have been several kilometres. The distribution of geomagnetic anomalies might suggest a volcanic field with volcanoes more frequent than can be seen nowadays, but owing to the subsequent erosion individual anomalies could also equally represent remnants of a former giant volcano.

In between the volcanoes deep water sedimentation took place. These basins were filled mainly by tuffites, fine grained weathering products and fine grained crinoidal fragments in suspension. Ammonites were the prevailing faunal inhabitants of this environment (see Kisújbánya, in Bujtor, 1993). The 0.5-m-thick breccia-conglomerate fan with a mass of shallow marine fossils (including *Valletia, Heterodiceras, Nerinea* and ostreid species) in the Kisújbánya Basin is interpreted as a major sedimentary depositional event, involving rapid transportation down-slope. The ripped-open and wrinkled siltstone bodies above the

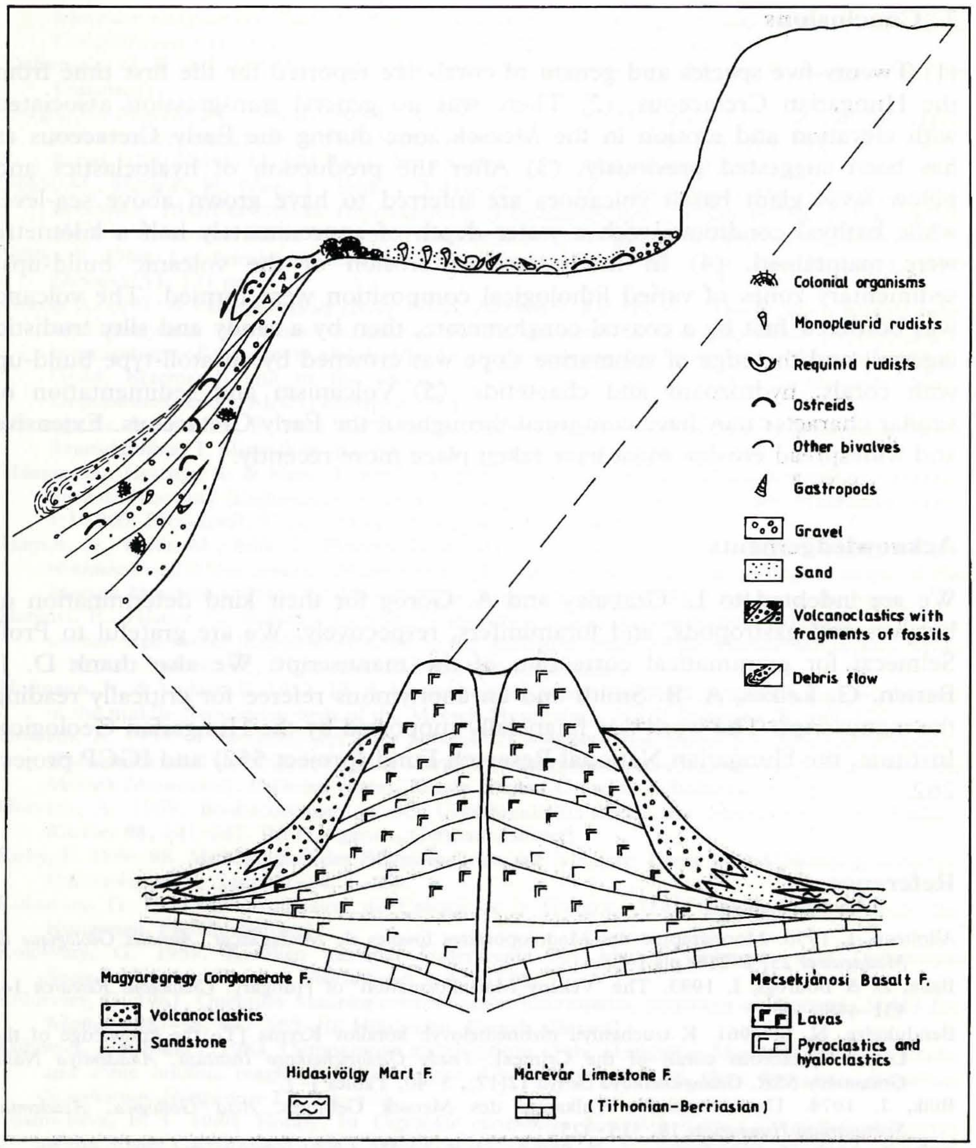

Figure 13. Reconstruction of litho- and biofacies distribution on the margins and slopes of Early Cretaceous volcanoes.

breccia indicate a levelling out but still gently dipping slope with pelagic limestone and calcareous marl layers deposited during a break in clastic sedimentation. Sediments of true basinal facies (Hidasivölgy Marl Formation) are found in the Hidasi valley and vicinity with a rhythmic alternation of limestone-calcareous marl and marl-clayey marl reflecting 3rd order sea-level fluctuation.

On the basis of lithologic composition and their fossil content the highest part of the former volcanic slope is represented in the Márévár valley section. The Mecsekjánosi section must have been in an intermediate position on the slope. There are not enough data for reconstruction from the vicinity of Vékény. It can be supposed that in addition to the pelagic environment an atoll-type shallow marine environment was maintained through to the Albian or Cenomanian.

7. Conclusions

(1) Twenty-five species and genera of corals are reported for the first time from the Hungarian Cretaceous. (2) There was no general transgression associated with elevation and erosion in the Mecsek zone during the Early Cretaceous as has been suggested previously. (3) After the production of hyaloclastics and pillow lavas giant basalt volcanoes are inferred to have grown above sea-level while bathyal conditions with a water depth of approximately half a kilometre were maintained. (4) In the course of erosion of the volcanic build-ups, sedimentary zones of varied lithological composition were formed. The volcano was bordered first by a coastal conglomerate, then by a sandy and silty 'rudistid lagoon', and the edge of submarine slope was crowned by an atoll-type build-up with corals, hydrozoans and chaetetids. (5) Volcanism and sedimentation of similar character may have continued throughout the Early Cretaceous. Extensive and widespread erosion must have taken place more recently.

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References

Alloiteau, J. 1958. Monographie des Madréoporaires fossiles de Madagascar. *Annales Géologique de Madagascar* **25**, 1–218, pls 1–38.

Balla, Z. & Bodrogi, I. 1993. The 'Vékény Marl Formation' of Hungary. *Cretaceous Research* **14**, 431–448.

Bendukidze, N. S. 1961. K izucheniyu nizhnemelovyh korallov Kryma [To the knowledge of the Lower Cretaceous corals of the Crimea]. *Trudy Geologicheskogo Instituta, Akademiya Nauk Gruzinskoy SSR, Geologicheskaya Seriya* **12**(17), 5–40, Tables 1–7.

Bilik, I. 1974. Unterkretazische Vulkanite des Mecsek Gebirges. *Acta Geologica, Academiae Scientiarium Hungaricae* **18**, 315–325.

Bilik, I. 1983. Lower Cretaceous submarine (rift) volcanism in South Transdanubia (South Hungary). In *Proceedings of the 17th Assembly of the European Seismological Committee, Budapest, 1980* (eds Bisztricsányi, E. & Szeidovitz, Gy.), pp. 569–574 (Akadémiai Kiadó, Budapest).

Bilik, I., Hámor G., Hetényi R. & Nagy, I. 1978. *Magyarázó a Mecsek hegység földtani térképéhez. 10 000-es sorozat. Kisbattyán* [Explanatory notes to the geological maps of the Mecsek Mountains. Series 1:10 000. Kisbattyán], 82 pp. (MÁFI Publication, Budapest).

Bujtor, L. 1993. Valanginian ammonite fauna from the Kisújbánya Basin (Mecsek Mts, South Hungary) and its palaeobiogeographical significance. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* **188**, 103–131.

Császár, G. 1985. A review of the Hungarian Middle Cretaceous key and reference sections. *Österreichische Akademie der Wissenschaften, Schriftenreihe der Erdwissenschaftlichen Kommission* **7**, 67–92.

Császár, G. & Haas, J. 1984. The Cretaceous in Hungary, a review. *Acta Geologica Hungarica* **27**, 417–428.

Császár, G., Friedel-Matyók, I. & Bodrogi, I. 1981. Cretaceous rocks drilled at Nagybaracska. *MÁFI Évi Jelentése* **1981**, 213–238. [In Hungarian, English abstract]

Czabalay, L. 1971. Pachyodontes Crétacées de la Montagne Mecsek. *MÁFI Évi Jelentése* **1968**, 185–205. [In Hungarian, French abstract]

Czabalay, L. 1991. *Jelentés a Magyaregregyi Konglomerátum Formáció kagyló- és csiga faunájának*

őslénytani vizsgálatáról [Report on the study of bivalves and gastropods in the Magyaregregy Conglomerate Formation]. Unpublished report, MÁFI, Budapest, 16 pp.
Dalrymple, G. B. & Lanphere, M. A. 1969. *Potassium-Argon dating*, 258 pp. (W. A. Freeman, San Francisco).
Forgó, L., Moldvay, L., Stefanovits, P. & Wein, Gy. 1966. *Magyarázó Magyarország 200 000-es földtani térképsorozatához. L-34-XIII Pécs* [Explanatory notes to the geological maps of Hungary. Series 1:200 000. L-34-XIII Pécs], 196 pp. (MÁFI Publication, Budapest).
Földi, M., Hetényi, R., Nagy, I., Bilik, I. & Hámor, G. 1977. *Magyarázó a Mecsek hegység földtani térképéhez. 10 000-es sorozat. Hosszúhetény-É* [Explanatory notes to the geological maps of the Mecsek Mountains. Series 1:10 000. Hosszúhetény-N], 88 pp. (MÁFI Publication, Budapest).
Fülöp, J. 1966. Les formations crétacées de la Montagne de Villány. *Geologica Hungarica, Series Geologica* **15**, 131 pp.
Görög, Á. 1991. *A Villányi-hegység (Bisse, Gyüd, Beremend) és a Mecsek (Vékény) alsó és középső kréta képződményeinek mikrofauna vizsgálata, különös tekintettel az Orbitolina-félékre* [Microfaunistic investigations of the Lower and middle Cretaceous formations in the Villány Mountains (Bisse, Gyüd, Beremend) and in the Mecsek (Vékény) with special regard to the orbitolines]. Unpublished report, MÁFI, Budapest, 28 pp.
Harangi, Sz. & Árva-Sós, E. 1993. Early Cretaceous volcanic rocks of the Mecsek Mountains (South Transdanubia) I. Mineralogy and petrology. *Földtani Közlöny* **122**, 129–165.
Hámor, G., Hetényi, R. & Nagy, I. 1967. *Magyarázó a Mecsek hegység földtani térképéhez. 10 000-es sorozat. Pécsvárad* [Explanatory notes to the geological maps of the Mecsek Mountains. Series 1:10 000. Pécsvárad], 57 pp. (MÁFI Publication, Budapest).
Hámor, G., Földi, M., Bilik, I., Hetényi, R. & Nagy, I. 1974. *Magyarázó a Mecsek hegység földtani térképéhez. 10 000-es sorozat. Magyaregregy* [Explanatory notes to the geological maps of the Mecsek Mountains. Series 1:10 000. Magyaregregy], 51 pp. (MÁFI Publication, Budapest).
Hetényi, R., Hámor, G. & Nagy, I. 1968. *Magyarázó a Mecsek hegység földtani térképéhez. 10 000-es sorozat. Apátvarasd* [Explanatory notes to the geological maps of the Mecsek Mountains. Series 1:10 000. Apátvarasd], 55 pp. (MÁFI Publication, Budapest).
Hofmann, K. & Vadász, E. 1912–13. A Mecsekhegység középső-neokom rétegeinek kagylói [Bivalves of the middle Neocomian beds of the Mecsek Mountains]. *MÁFI Évkönyve* **20**, 189–226.
Horváth, A. 1959. *A mecsekhegységi kréta homokkő és konglomerátum rétegcsoport őslénytani vizsgálata* [Palaeontological investigation of the Cretaceous sandstone and conglomerate formations of the Mecsek Mountains]. Diploma report, Eötvös Loránd University, Budapest, 82 pp.
Horváth, A. 1968. Beobachtungen in der Unterkreide-Schichten des Mecsek-Gebirges. *Földtani Közlöny* **98**, 241–247. [In Hungarian, German abstract]
Koby, F. 1896–98. Monographie des Polypiers Crétacéde la Suisse. Partie 1–3. *Mémoires de la Société Paléontologique de Suisse* **22–24**, 1–100.
Kolosváry, G. 1954. Les coralliaires du Crétacé de la Hongrie. *MÁFI Évkönyve* **42**, 67–163. [In Hungarian, French abstract]
Kolosváry, G. 1959. Korallen aus der Unterkreide des Mecsek Gebirges. *Acta Universitatis Szegediensis. Acta Biologica. Nova Series* **5**, 125–128.
Kolosváry, G. 1961. Quelques Madréoporaires fossiles intéressants, nouveaux en Hongrie. *MÁFI Évi Jelentése* **1957–58**, 497–503. [In Hungarian, French abstract]
Kubovics, I. & Bilik, I. 1984. Comparative investigations of the Hungarian Mesozoic mafic-ultramafic and some ofiolitic magmatic rocks in the Alp-Carpathian chain. *Acta Geologica, Academiae Scientiarium Hungaricae* **27**, 321–339.
Kusmicheva, E. I. 1980. Koraly. In *Urgonskie otlozheniya Sovetskih Karpat* [Urgonian sediments of the Soviet Carpathians] (eds Chernov, V. G., Yanin, B. T., Golovinova, M. A., Gorbachik, T. N. *et al.* (3 other authors)), *Akademiya Nauk SSSR*, pp. 90–108 (Izdatel'stvo Nauka, Moskva).
Kusmicheva, E. I. & Pyanovskaya, I. A. 1970. Conditions of burial, systematic composition and ecological pecularities of the Albian scleractiniens of the central Kysylkum. *Vestnik Moskovskogo Universiteta* **4**, 70–74. [In Russian, English abstract]
Löser, H. 1989. Die Korallen der Sächsischen Oberkreide. Teil1: Hexacorallia aus dem Cenoman. *Abhandlungen des Staatlichen Museums für Mineralogie und Geologie zu Dresden* **36**, 88–154.
Mauritz, B. 1913. A Mecsek-hegyaség eruptivus kőzetei [Eruptive rocks of the Mecsek Mountains]. *MÁFI Évkönyve* **21**, 151–190.
Molnár, K. 1962. *Jelentés a Magyaregregy környékén az 1962, évben végzett részletes földmágneses mérések eredményeiről* [Report on the detailed magnetic measurements in the Magyaregregy area in 1962]. Unpublished report, MÁFI, Budapest, 10 pp.
Molnár, K. 1963. *Jelentés az 1963, évben Zengővárkony és Máza környékén végzett részletes földmágneses mérések eredményeiről* [Report on the detailed magnetic measurements in the vicinity of Zengővárkony and Máza in 1963]. Unpublished report, MÁFI, Budapest, 4 pp.
Molnár, K. 1964. *Jelentés az 1964, évben Kisújbánya és Kisbattyán között végzett részletes földmágneses mérések eredményeiről* [Report on the detailed magnetic measurements between Kisújbánya and Kisbattyán]. Unpublished report, MÁFI, Budapest, 9 pp.

Morycowa, E. 1964. Hexacorallia des couches de Grodziszcze (Néocomien, Carpathes). *Acta Palaeontologica Polonica* **9**, 1–114.
Morycowa, E. 1971. Hexacorallia et Octocorallia du Crétacé inférieur de Rarau (Carpathes Orientales Roumaines). *Acta Palaeontologica Polonica* **16**, 1–149.
Nagy, I., Földi, M., Hámor, G. & Hetényi, R. 1973. *Magyarázó a Mecsek hegység földtani térképéhez. 10 000-es sorozat. Kárász* [Explanatory notes to the geological maps of the Mecsek Mountains. Series 1:10 000. Kárász]. I–III, Unpublished report, MÁFI, Budapest, 47 pp.
Nagy, I., Hámor, G., Hetényi, R., Bilik, I. & Földi, M., 1978. *Magyarázó a Mecsek hegység földtani térképéhez. 10 000-es sorozat. Kisújbánya* [Explanatory notes to the geological maps of the Mecsek Mountains. Series 1:10 000. Kisújbánya], 88 pp. (MÁFI Publication, Budapest).
ifj. Noszky, J. 1948. *A Komló környéki szénterület földtani viszonyai* [Geological setting of the Komló coal field]. Unpublished report, MÁFI Budapest, 48 pp.
ifj. Noszky, J. 1952. Conditions géologique du terraine houiller des environs de Komló. *MÁFI Évi Jelentése* **1948**, 65–77. [In Hungarian, French abstract]
Preobrazhensky, M. B. 1990. Urgonian lithofacies and fauna of the Kopetdag Basin, southern USSR. *Cretaceous Research* **11**, 247-252.
Prever, P. L. 1909. La fauna coralligena del cretaceo dei Monte d'Ocre nell' Abruzzo Aquilano. *Memorie Descritive della Carta Geologica d' Italia* **5**, 61–147.
Prinz, P. 1991. Mesozoische Korallen aus Nordchile. *Palaeontographica A* **216**, 147–209.
Scott, R. W., Fernandez-Mendiola, P. A., Gili, E. & Simo, A. 1990. Persistence of coral-rudist reefs into the Late Cretaceous. *Palaios* **5**, 98–110.
Sidó M. 1961. Mikropaläontologische Untersuchung der Oberkreideschichten des Vékényer Tales. *MÁFI Évkönyve* **49**, 807–824.
Siharulidze, G. Ja. 1979. Albskie korally sela Chanari (Zapadnaya Gruziya) [Albian corals at the village of Chanari (Western Georgia)]. *Trudy Geologicheskogo Instituta, Akademiya Nauk Gruzinskoy SSR, Novaya Seriya* **63**, 1–49.
Siharulidze, G. Ja. 1985. Geksakorally urgonskoy facii Dzirulskogo Massiva i ego severnogo obramleniya [Hexacorals of the Urgonian facies of the Dzirula Massive and its northern margin]. *Trudy Geologicheskogo Instituta. Akademiya Nauk Gruzinskoy SSR, Novaya Seriya* **88**, 1–78.
Szepesházy, K. 1966. Rocks of the Cretaceous volcanic area between Kecskemét and Szolnok. *MÁFI Évi Jelentése* **1964**, 525–534. [In Hungarian, English abstract]
Szepesházy, K. 1973. *A Tiszántúl északnyugati részének felsőkréta és paleogén korú képződményei* [Upper Cretaceous and Palaeogene formations of the northwestern part of the Trans-Tisza region], 95 pp. (Akadémiai Kiadó, Budapest).
Turnšek, D. & Buser, S. 1974. The Lower Cretaceous corals, hydrozoans and chaetetids of Banjöka planota and Trnovski gozd. *Razprave, Slovenska Akademija Znanosti in Umetnosti. IV. Razred za Prirodoslovne Vede* **17**, 81–124. [In Slovenian, English abstract]
Turnšek, D. & Masse, J. P. 1973. The Lower Cretaceous Hydrozoa and Chaetetidae from Provence (south-eastern France). *Razprave, Slovenska Akademija Znanosti in Umetnosti. IV. Razred za Prirodoslovne Vede* **16**, 217–244.
Turnšek, D. & Mihajlovič, M. 1981. Lower Cretaceous cnidarians from eastern Serbia. *Razprave, Slovenska Akademija Znanosti in Umetnosti. IV. Razred za Prirodoslovne Vede* **23**, 1–54.
Vadász, E. 1912. Néhai Hofmann Károly: A Mecsekhegység középső neokom kagylói [The late Károly Hofmann: middle Neocomian bivalves of the Mecsek Mountains]. *Mathematikai és Természettudományi Értesítő* **30**, 688–693.
Vadász, E. 1935. Das Mecsek-Gebirge. *Magyar Tájak Földtani Leírása* **1**, 180 pp. [In Hungarian, German abstract]
Wein, Gy. 1965. Az "északi-pikkely" a Mecsek hegységben [The 'Northern Imbrication' in the Mecsek Mountains]. *Bányászati és Kohászati Lapok* **98**, 402–411.
Wein, Gy. 1967. Über die Tektonik Südost-Transdanubians. *Földtani Közlöny* **97**, 371–395. [In Hungarian, German abstract]