

The facies zonation and scleractinians of the early Hauterivian reef complex of Bolshoy Balkhan

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A reef system of Hauterivian age that is situated on the south side of Bolshoy Balkhan (Turkoman Republic) has been investigated. Research on a number of sections has allowed the reconstruction of the palaeogeography of the underwater slope as developed along the isochronous surface. On the basis of the lithological composition of, and fossil communities in, the deposits, 10 facies distributed within three zones of the palaeobasin have been identified. There was a favourable environment for the establishment of numerous reef-builders, mainly scleractinian corals. New data concerning their dispersal, systematics, morphological types and epibiont fauna have been obtained. Twenty-six forms of scleractinians belonging to 16 genera from this region have been identified. A study of the reef deposits allowed the reconstruction of the conditions of their formation and revealed regular links between species and growth forms of scleractinians and facies of certain types. The majority of the corals occur in the Urganian of many other parts of the Tethyan region. Bolshoy Balkhan is another area where the Urganian biosedimentary system began before the Barremian.

KEY WORDS: Turkoman Republic; Hauterivian; reef complex; facies types; scleractinian corals; palaeoecology; Urganian.

1. Introduction

Reef deposits of Hauterivian–Barremian age are widely distributed in the territory of the Turkoman Republic (Bugrova *et al.*, 1985, 1987; Bugrova, 1986). These occur mainly in the zone of Alpine folding. Following a recent thorough investigation in the mountains of Kopetdag, Bolshoy Balkhan and Maliy Balkhan, a general regularity in the sequence of facies in the reef systems has been revealed. A great variety of lithologies and faunas characterize the system (Bugrova & Preobrazhensky, 1987). While studying the geological sections the facies zones of some reef complexes were identified. In this respect, the reef system of the Alikper Formation (Hauterivian), situated on the south side of the Bolshoy Balkhan meganticline, has turned out to be one of the most interesting and representative associations. It has been investigated in detail by M. Preobrazhensky.

The most diverse assemblage of scleractinians has been found in the Hauterivian deposits. Unfortunately, on account of incomplete preservation, not all of the corals could be identified to species level. In all, 26 forms belonging to 16 genera from the Hauterivian of the Bolshoy Balkhan have been found. Eighteen of these were identified to species. There are only five endemic forms in the fauna; the majority of species also occur in the Urganian of other regions (Table 1).

2. Zonation of the reef complex

Research on a number of Hauterivian sections on the southern slope of Bolshoy Balkhan has resulted in the reconstruction of the palaeogeography of the underwater slope as developed along the isochronous surface. Several zones were identified by

Table 1. Scleractinian species from the Alikper Formation and their stratigraphical and geographical distribution.

Scleractinians	Bolshoy Balkhan Western outcrops					Eastern outcrops
	Facies					
	A	B	C	D	E	
<i>Actinastraea kugusemensis</i> Kusmicheva			X			
<i>A. colliculosa</i> (Trautschold)				X	X	
<i>Stylosmia alpina</i> Koby				X	X	
<i>Stylosmia</i> sp.				X		
<i>Stylna elegans</i> Eichwald				X		
<i>S. regularis</i> Fromentel					X	
<i>Heliocoenia pseudocoralina</i> Sikharulidze						X
<i>Heliocoenia</i> sp.1			X			
<i>Heliocoenia</i> sp.2						X
<i>Montivaltia orientalis</i> Bugrova	X			X		
<i>Lathyphyllia</i> sp.					X	
<i>Dimorphocoenia crassisepta</i> Solomko						X
<i>Peplosmia</i> cf. <i>taurica</i> Kusmicheva					X	
<i>Peplosmia</i> sp.					X	
<i>Placophyllia curvata</i> Turnšek				X		
<i>Thamoseris</i> sp.	X	X		X		X
<i>Fungiastraea tendagurensis</i> (Dietrich)				X	X	
<i>Fungiastraea</i> sp.	X	X		X		
<i>Stereocoenia collinaria</i> (Fromentel)				X		
<i>Microsolena crassisepta</i> Sikharulidze	X	X			X	X
<i>M. distefanoi</i> (Prever)	X	X		X	X	
<i>M. exigua</i> Koby			X			
<i>Dermosmia cretatica</i> Turnšek				X	X	
<i>Calamophylliopsis compressa</i> (d'Orbigny)					X	
<i>Microphyllia undans</i> (Koby)	X	X	X	X	X	
<i>Microphyllia thurmanni</i> Etallon						X

km—Kimmeridgian; ox—Oxfordian; ox₂—upper Oxfordian; t—Tithonian; v—Valanginian; h—Hauterivian; br—Barremian; a—Aptian; a₁—lower Aptian; alb—Albian; + Urgonian

Preobrazhensky (in Bugrova & Preobrazhensky, 1987). They are as follows (from NE to SW):

1—coastal; 2—nearshore shallow sea with a border of patch reefs on the southern edge (clastic material from the shore and carbonate material from the corallgal barrier being brought alternately to this area); 3—shallower sea with the banks of rudists landward of framework facies; 4—shallow sea of back-reef calcarenite dunes; 5—corallgal barrier; 6—fore-reef talus; 7—pelagic muds.

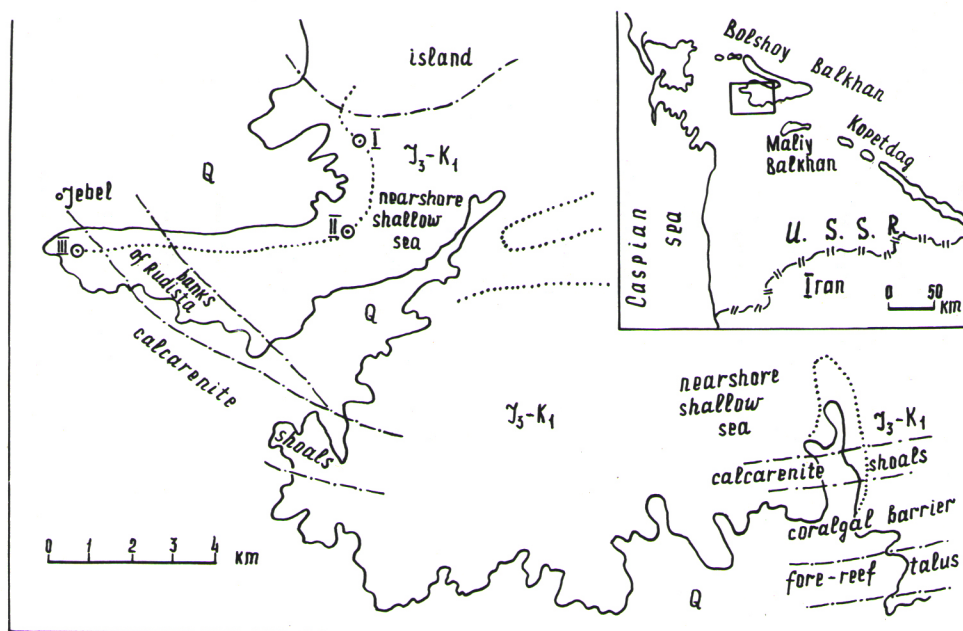
In a section in the western part of the south slope of Bolshoy Balkhan (Figure 1) the second, third and fourth zones can be traced. The total thickness of the deposits under discussion varies from 5 to 15 m. They lie on an eroded surface of dolomite which formed the lithified basement of the shallow Hauterivian sea. This provided a favourable environment for establishment of numerous reef-builders. After examining the lithological composition and fossil communities of these deposits it has been possible to identify some facies types within the zones (in Figures 2 and 3 these are labelled A–J).

Other areas																
Maiy Balkhan	Kopetdag	Mangyshlak	Georgia	Armenia	Azerbaijan	Soviet Carpathians	Crimea	Romania	Poland	Yugoslavia	Czechoslovakia	France	Switzerland	Afghanistan	East Africa	South America
		v h	h ⁺	br ⁺			h			br - a ⁺		h	h		h	h
			h ⁺ br ⁺ br ⁺				h	a ₁ ⁺	br - a ₁ ⁺	br - a ₁ ⁺		a ₁ ⁺				
							h		h - a ₁ ⁺							
	h					br - a ⁺				br - a ⁺						
br ⁺					br ⁺	br - a ⁺			br - a ⁺					br ⁺	h	
br ⁺		v				br - a ⁺		a ₁ ⁺				h				
br ⁺			h ⁺			br - a ⁺			h - a ⁺	br - a ⁺						
			h ⁺ h ⁺ alb			br - a ⁺		ox ₂		br - a ⁺		ox ₂	ox ₂			
					br ⁺	br - a ⁺			t ₂ , br - a ⁺	ox, v	t ₂			h	br ⁺ km	
									t ₁ , br - a ⁺		t				km	

3. Description and distribution of facies

Facies A is represented by corallgal bindstone and framestone with an argillaceous admixture and large massive loaf-like colonies about 30–40 cm across and 10 cm in height. The type A assemblage includes *Microsolena crassisepta* Sikharulidze, *M. distefanoi* Prever, *Microphyllia undans* (Koby), *Fungiastraea* sp., *Montlivaltia orientalis* Bugrova, and *Thamnoseria* sp. The majority of intact colonies (especially at the base of the bed) have been found in growth position, but many redeposited corals are also present, showing all degrees of fragmentation and tilting.

The space between the colonies is filled with an argillaceous floatstone of rolled fragments of the same corals. In addition, a large number of shells of brachiopods have been found (*Cycolthyris irregularis* Pictet, *Loriolithyris russilensis* Loriol and some new forms) along with gastropods, bivalves (*Arca* cf. *sanctacrucis* Pictet & Campiche, *Exogyra subsinuata* Leymerie, *Pterotrignonia carinata* Agassiz, *Plectomya* aff. *agassizi* d'Orbigny, *Panope* cf. *cilindrica* Pictet & Campiche), regular echinoids (*Goniopygus*



- J₃-K₁ Upper Jurassic-Lower Cretaceous deposits
- Q recent deposits
- contour of the outcrops of the carbonate complex
- outcrops of coral-rich deposits of the Alikper Formation
- boundaries of palaeogeographical zones
- II points on the section (Figure 2)

Figure 1. Palaeogeographical zones of the Alikper Formation (Lower Hauterivian) of Bolshoy Balkhan.

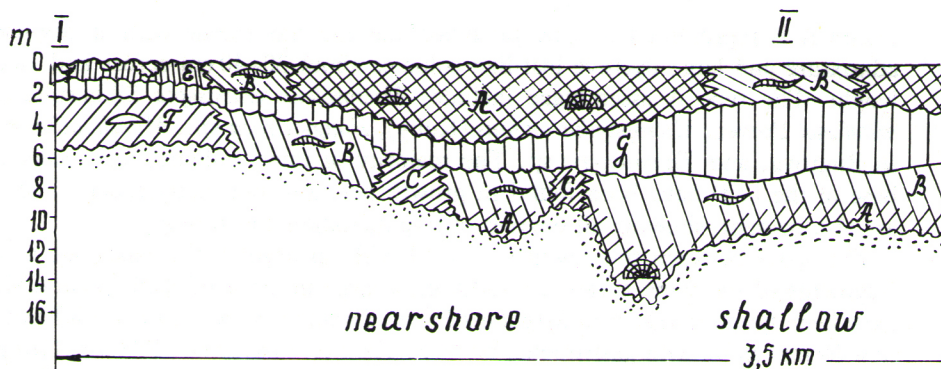


Figure 2. Biofacies zonation of coralline deposits of the Alikper Formation along the line I-II-III in Figure 1 (horizontal plot not to scale); see Figure 3 for legend.

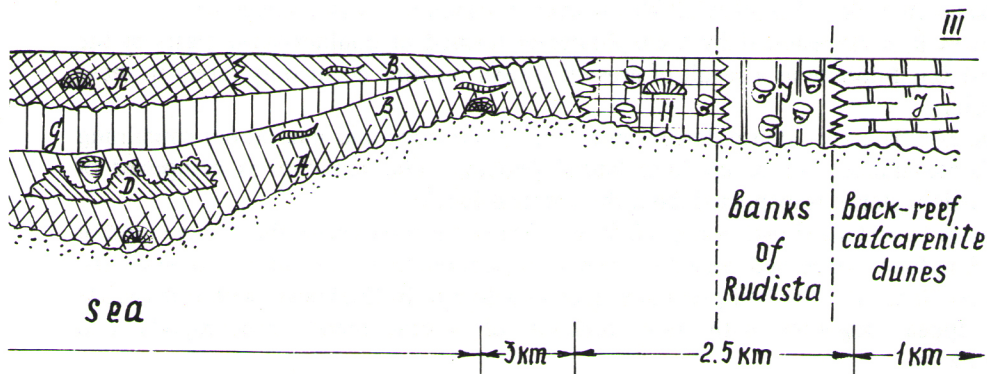
peltatus Agassiz, *Hyposalenia stellulata* (Agassiz), *Codiopsis lorini* Cotteau), serpulid worms and sponges, foraminifers and algae. This A facies represents localized deposition on the sea bottom; the dominant fauna could grow only on lithified surfaces.

The composition of facies type B is quite similar. By contrast to type A it consists of conglomerate-like but much more argillaceous soft nodular limestone. The wavy bedding is emphasized by crust-shaped colonies of hexacorals. The same species of scleractinians have been found there, but they are smaller and the epibionts are less diverse. Traces of local erosion can be observed everywhere in the form of uneven surfaces with ferrugination and desiccation cracks. Owing to frequent silting and subaerial exposure, environmental conditions clearly became quite unfavourable to the reef builders. The deposits of facies A and B replace each other both along strike and in section.

Between facies types A and B, there are others, such as C, D and E, which formed local bioherms, and F which consists of a carbonate lithoclastic boulder conglomerate. These buildups differ in shape and in the assemblage composition of reef-builders and other fauna.

Facies C is represented by simple dome-shaped bioherms of only modest size. They are not more than 2 m high and 5 m in diameter. Distances between these buildups are much greater than their own dimensions. The bioherms are constructed of large, massive and dendroid colonies of corals that have grown directly on one another. The following have been recognized: *Actinastraea kugusemensis* Kusmicheva, *Heliocoenia* sp. 1, *Microphyllia undans* (Koby) and *Microsolena exigua* Koby. The gaps between buildups are occupied by clayey limestone containing remains of the same species as in facies B.

The most diversified association of scleractinian forms has been found in bioherms of facies D and E. Facies D comprises simple bioherms 1–2 m high and 3–4 m across. They are constructed of large colonies of all known types and various shapes. Moreover, extremely large calices of *Montlivaltia orientalis* Bugrova have been found only in this facies. From the deposits of this type *Actinastraea colliculosa* (Trautschold), *Stylosmilia alpina* Koby, *Stylosmilia* sp., *Stylina elegans* Eichwald, *Placophyllia curvata* Turnšek, *Microphyllia undans* (Koby), *Thamnosseris* sp., *Fungiastraea tendagurensis* (Dietrich), *Fungiastraea* sp., *Stereocoenia collinaria* (Fromentel), *Microsolena distefanoi* (Prever) and *Dermosmilia cretatica* Turnšek have



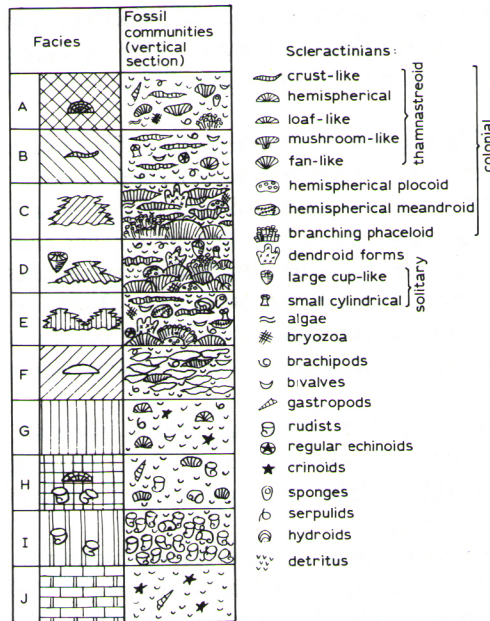


Figure 3. Fossils and palaeoecological features of the coralline deposits of the Alikper Formation.

been obtained together with brachiopods, gastropods, bivalves and other fossils. The epibionts are the same as those of facies A.

Facies E is mainly composed of complex (lens-like or dilophoid) bioherms with a broad base, 8–9 m in diameter. The distance between them is not more than 7 m. Some other forms of scleractinians have been described from this facies, but the shapes and sizes of these colonies are the same as those of the buildups of facies D. Corals are abundant and the following scleractinian species have been identified: *Actinastraea colliculosa* (Trautschold), *Stylosmilia alpina* Koby, *Stylina regularis* Fromentel, *Calamophylliopsis compressa* (d'Orbigny), *Lathyphyllia* sp., *Peplosmilia* cf. *taurica* Kusmicheva, *Peplosmilia* sp., *Microphyllia undans* (Koby), *Fungiastraea tendagurensis* (Dietrich), *Microsolena crassisepta* Sikharulidze, *M. distefanoi* Koby and *Dermosmilia cretacica* Turnšek. A great many epibionts have been found together with scleractinian corals (see facies D). The most common and characteristic genera for facies A–E are *Microphyllia*, *Microsolena*, *Fungiastraea* and *Thamnosieris*.

Facies F is represented by a conglomerate formed of boulder-sized clasts of the underlying dolomite as a result of erosion. Fossil remains occur only rarely in these deposits.

Facies G is a very dense detrital limestone (grainstone and packstone) containing negligible amounts of redeposited faunal remains. The sediment is composed of bioclastic material transported from the coralgal barrier.

Facies H was identified in the northwest part of the area where the composition of the limestone concerned becomes richer in carbonate when compared with the adjacent facies B. The bed gradually decreases to 5 m in thickness; within it rudists first appear together with rare remains of scleractinians, brachiopods and gastropods.

All of these facies formed in a zone of shallow sea, near shore. Despite taxonomic differences between recent and ancient corals, similarly shaped scleractinians can be

observed in comparable zones of the modern lagoons. For example, the same forms of colonies as in the Hauterivian of Bolshoy Balkhan have been described from the Swain group of extant Australian reefs (Krasnov & Klaamaan, 1982). The spherical and hemispherical colonies of *Platygyra*, *Leptoria*, *Favites* and *Goniastrea* inhabit the bottom of the circular Australian reefs. The same conditions in the Early Cretaceous basin led to the development of massive loaf-shaped and hemispherical colonies of *Microsolena*, *Fungiastrea*, *Microphyllia* and *Thamnoseria*. The largest recent patch reefs are surrounded at their bases by phaceloid colonies of *Acropora* and *Seriatipora*, so *Stylosmilia* seems to be their Lower Cretaceous equivalent. The areas of sea-floor between the modern reefs are occupied by saucer-shaped *Acropora*; in their morphology and location they show a great similarity to the Early Cretaceous corals *Microphyllia* and *Microsolena*.

Facies I consists of dense, massive limestone (coquina) with numerous remains of the rudist *Requienia*. It grades laterally towards the west into facies J, which consists of dolomitized calcarenites with many fragmented *Crinoidea*. These deposits are thought to be representative of back-reef dunes (4th zone).

3. Comparison with surrounding areas

The composition of the beds under discussion changes to the east. The same facies zonation can be traced there, except for the rudist banks. In the second zone the thickness of the bed concerned reaches only 1 m, but it increases from the second to fifth zones by as much as 20 m. The faunal assemblage is similar to the associations found in the western part, but it is much less diverse. Characteristic corals of facies A and B can be found, including *Microphyllia undans* (Koby), *Thamnoseria* sp., *Microsolena crassisepta* Sikharulidze, *Heliocoenia pseudocorallina* Sikharulidze, *Heliocoenia* sp., *Dimorphocoenia crassisepta* Solomko and *Microphyllia thurmanni* Etallon. The ecological character of the colonies changes. In the east the largest Hauterivian forms of the region have been described. For example, the large hemispherical and high dendroid forms found may reach as much as 80 cm in diameter and 50 cm in height. Such colonies were generally attached to the lowest parts of the shallow sea bottom. Most are preserved in their life position. The sequence of sediments and growth forms of corals is very similar to that of recent reefs in the Indian Ocean and Caribbean Atlantic areas (Hubbard, 1983, p. 5, text-figure 4). In the eastern part of the Hauterivian sea of Bolshoy Balkhan the corals inhabited fairly turbulent hydrodynamic conditions and suffered less from silting than those in the western part of the basin.

4. Conclusions

A comprehensive study of reef deposits of the lower part of the Hauterivian of Bolshoy Balkhan has enabled the conditions of their formation to be reconstructed. It has been possible to draw conclusions about the depth, hydrodynamics and relief of the bottom of the palaeobasin and to establish that there were regular associations of species and genera of scleractinians with facies of certain types, and that these are similar to modern associations. The precise age of the deposits could not be determined by corals alone, but they may be safely considered to be not older than early Hauterivian. The section is dated as Hauterivian on the basis of the occurrence of other faunal groups.

Most of the scleractinian corals on the southern wing of Bolshoy Balkhan occur

widely in Urgonian strata of the Trans-Caucasian area (Sikharulidze, 1985; Kusmicheva & Aliev, 1988), the Carpathian mountains (Morycowa, 1964, 1971; Turnšek & Buser, 1974; Kusmicheva, 1980), Switzerland (Koby, 1896–1898), France (Fromentel, 1857, 1862–1887) and elsewhere. Many species typical of the Urgonian have been discovered in Barremian strata of the northern part of Bolshoy Balkhan, the western part of Maliy Balkhan (Kusmicheva, 1987) and Tuarkyr. This fauna contains fewer endemic species than that in the Hauterivian rocks. The development of typically Urgonian scleractinians in the south of Central Asia is believed to be more representative of the Barremian stage than of the Hauterivian.

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