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THE APTIAN STRATIGRAPHY OF SOUTHERN TUARKYR (NW TURKMENISTAN, CENTRAL ASIA)

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Riassunto. Le successioni ammonitifere del Turkmenistan, quelle del Greater Balkhan e del Tuarkyr in particolare, sono considerate di riferimento per l'Aptiano. Sei sezioni relative all'intervallo Barremiano sommitale - base dell'Aptiano superiore sono state rilevate nella regione del Tuarkyr nell'ottobre del 1997. Sono state raccolte faune ad ammoniti e bivalvi. I dati ricavati sono confrontati con quelli provenienti da un'altra sezione studiata nel 1959 da una missione russa. La distribuzione stratigrafica delle faune è discontinua. Nell'intervallo studiato le faune ad ammoniti sono caratterizzate da bassa diversità, espressa dalla dominanza del genere *Deshayesites* nell'Aptiano inferiore e del genere *Epicheloniceras*, associato con il meno frequente *Caspianites*, alla base dell'Aptiano superiore. Esistono specie comuni con Caucaso, Inghilterra, Germania, Francia e Svizzera e quindi le faune riflettono un impoverimento più che un isolamento geografico. L'equivalenza cronologica della Zona ad *Epicheloniceras subnodosocostatum* in Turkmenistan con la Zona ad *Epicheloniceras martinioides* in uso in Inghilterra è messa in discussione in quanto i livelli ad *Epicheloniceras* del Tuarkyr corrispondono alla parte superiore della Zona a *E. martinioides*, cioè alla Sottozona a *Epicheloniceras buxtorfi*. La fauna a bivalvi è composta principalmente da pteriidi, Exogyrinae e trigoniidi. Questi gruppi indicano chiaramente un ambiente marino con acque molto basse ed abbastanza calde, tipico per il Cretaceo inferiore della Tetide. Gli eterodonti sono troppo rari per dare ulteriori precisazioni batimetriche. Nessuno dei gruppi presenti indica comportamento infaunale profondo e tutti sono considerati littorali. La fauna a bivalvi presenta forti affinità con quella del "Lower Greensand" inglese.

Abstract. The ammonite successions of Turkmenistan, particularly those of the Greater Balkhan and Tuarkyr areas, are considered references for the Aptian Stage. Six sections across the uppermost Barremian - basal Upper Aptian interval were studied in the Tuarkyr desert in October 1997, and ammonites and bivalves were collected. Data are compared with those from a section sampled by a Russian team in 1959. The stratigraphic distribution of the faunas in the sections is discontinuous, as the fossiliferous levels intercalate with terrigenous sediments. The ammonite faunas, at least in the intervals sampled, show low diversity and are dominated by the genus *Deshayesites* in the lower Aptian and the genus *Epicheloniceras*, associated with the less common *Caspianites*, in the basal upper Aptian. The Turkmenistan sections contain species present also in the Caucasus, England, Germany, France and Switzerland, indicating that the Turkmenian faunas reflect impoverishement rather than geographic isolation. The chronologic equivalence between the Turkmenian *Epicheloniceras subnodosocostatum* Zone and the *Epicheloniceras martinioides* Zone in England seems questionable because the *Epicheloniceras-bearing* beds of the Tuarkyr correspond to the upper part of the *E. martinioides* Zone, i. e. the *Epicheloniceras buxtorfi* Subzone. The bivalve fauna consists mainly of pteriids, Exogyrinae oysters and trigoniids. These groups undoubtedly indicate a very shallow, fairly warm and fully marine environment, typical of the Tethyan Lower Cretaceous. The heterodonts are too rare to give further bathymetric indications. None of the taxa indicate deep burrowing and all are assumed to be very littoral. The bivalve fauna shows strong affinities with that of the English Lower Greensand.

Introduction.

During October 1997 one of the authors (F.C.) carried out a survey of the Aptian succession in the southern Tuarkyr area (northwestern Turkmenistan, Fig. 1).

The Aptian successions of Turkmenistan were studied in detail during the '60s and '70s by Soviet teams, especially in the Greater Balkhan and in the Tuarkyr area. Several publications have been devoted to geologic and stratigraphic themes (Resolution of the Interdepartmental Stratigraphic Commission, Samarkand, 1977; The stratigraphy of the USSR, 1986; Bogdanova & Tovbina 1995; Bogdanova et al., 1989; Preobrazhensky, 1990; Prosorovsky, 1990; Tashliev & Tovbina, 1992) and to ammonite palaeontology (Tovbina, 1963; Bogdanova, 1971a, b, 1977, 1978, 1979, 1983, 1991; Kakabadze et al., 1978).

The last subject is particularly important because the ammonite succession of Turkmenistan is considered a reference for the Barremian - Aptian boundary. In fact, the Working Group on Lower Cretaceous Cephalopods

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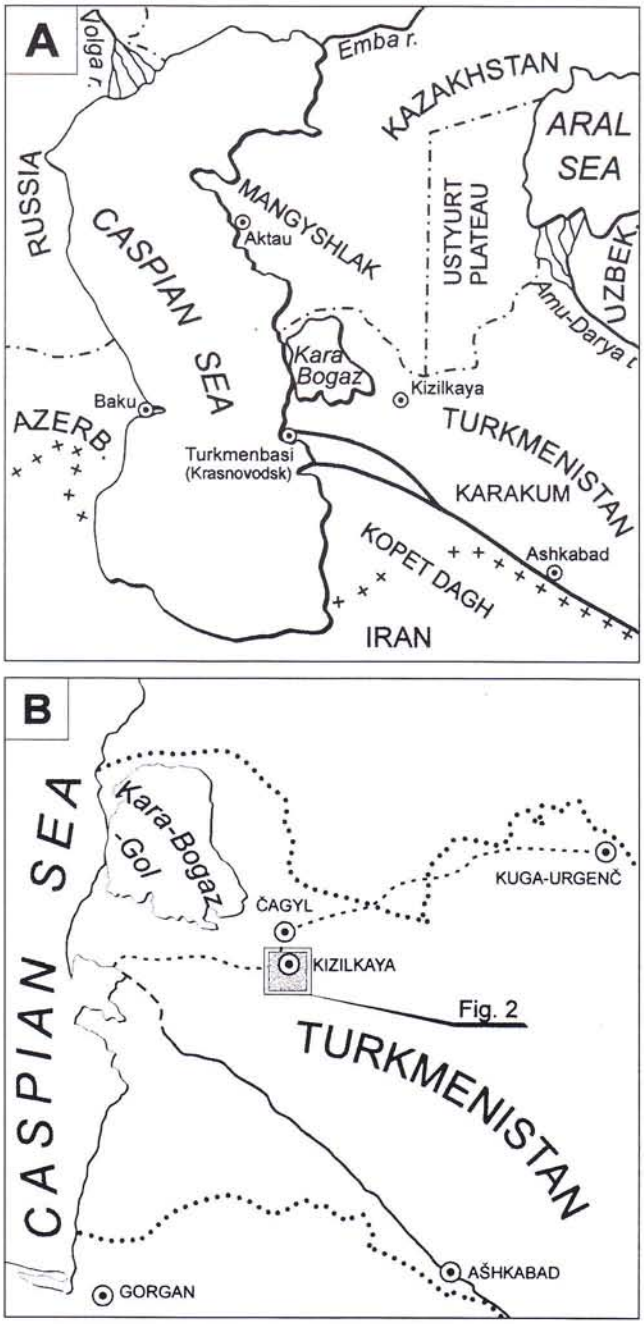


Fig. 1 - Location of the study area, south of Kizilkaya.

(Hoedemaeker & Bulot, 1990; Hoedemaeker & Company, 1993; Hoedemaeker & Cecca, 1995) retained for the zonation of the Mediterranean area the *Deshayesites tuarkyricus* Zone, which was defined in Turkmenistan as the basal ammonite zone of the Aptian (Bogdanova, 1971a). The topmost ammonite Zone of the Barremian in Turkmenistan, the *Turkmeniceras turkmenicum* Zone, was proposed as a horizon in the first version of the Mediterranean zonation (Hoedemaeker & Bulot, 1990).

Bogdanova & Tovbina (1995) and Bogdanova & Lobacheva (1995) proposed the Greater Balkhan area as the type-region for the selection of the stratotype of the Aptian boundary.

However, the Working Group on the Aptian stage (Erba, 1996) did not take into account the Turkmenian sections because, according to the standards normally required for stratotype definitions, no sufficient biostratigraphic information was available at the time. Despite the numerous palaeontologic papers on ammonites, no detailed stratigraphic logs of the Turkmenian sections were published and no further information was available, except for faunal lists and general lithologic characteristics of the sections. The stratigraphic data reported by Bogdanova (1971a) gave the impression of a discontinuous distribution of the faunas in the Turkmenian sections.

The expedition in the southern Tuarkyr region was undertaken to clarify the precise stratigraphic distribution of the numerous Turkmenian ammonite species and to provide a detailed description of sections.

Geologic setting and localities studied.

The Tuarkyr area is located in NW Turkmenistan (Fig. 1), east of the Karabogaz Gol. It is characterized by an anticline striking NW-SE with a Permo-Triassic core. A smaller anticline (Fig. 2) with a Jurassic core surrounded by Lower Cretaceous formations is present south of the periclinal closing of the anticline.

The general stratigraphic features of the pre-Aptian Lower Cretaceous succession, as described in the Resolution of the Samarkand Congress (Interdepartmental Stratigraphic Commission, 1977), are from top to bottom:

interval d) sandstones and siltites with intercalations of shales and limestones containing ammonites (*Turkmeniceras*, *Matheronites*) and bivalves; 25-35 m. Uppermost Barremian;

interval c) siltites and shales with intercalated shelly bioclastic levels. The most common fossils are bivalves (*Gervillia*, trigoniids etc.), although ammonites of the *Imerites giraudi* Zone (*Colchidites* gr. *colchicus*, *Imerites favrei*, *I. giraudi*) have been reported (Tovbina, 1963; Bogdanova, 1971a); 20-40 m. Upper Barremian;

interval b) calcarenites and intercalated marls and shales, with abundant orbitolinids, bivalves (exogyrine oysters) and brachiopods; 12-50 m. Hauterivian - Barremian;

interval a) dolostones and limestones with intercalated shaly levels overlying unconformably Callovian strata; bivalves (exogyrine oysters) indicative of a shallow-marine environment are the most common fossils; about 60 m. Hauterivian.

Prosorovsky (1990) included intervals a) and b) in the Urgonian facies though transitional facies to continental deposits occur in the southern Tuarkyr . Intervals c) and d) form the second Urgonian cycle described by Preobrazhensky (1990) and represent a marine regression pre-dating the major deepening of the basin that led

to the deposition of the Lower Aptian shaly succession (Preobrazhensky, 1990; Prosorovsky, 1990).

It is worth noting that the succession of the southern Tuarkyr studied in the present paper shows the characteristics that in Prosorovsky's (1990, fig. 2) stratigraphic scheme define his "Cubadag foredeep" more than the "Tuarkyr anteclise", the latter probably referring to the northern Tuarkyr and not to the area studied in the present paper.

Description of the stratigraphic sections.

Six sections were studied near the village of Geokdere (Fig. 2, 3):

1 - SW Mount Bishik, starting 13 km south of Geokdere;

2 - NE flank of Mount Bishik, 8 km south of Geokdere;

3 - Tekedjik 1, located in a canyon 4.5 km east of Geokdere;

4 - Tekedjik 2, 4 km east northeast of Geokdere;

5 - S Mount Hanbegiiburun, 3.5 km northeast of Geokdere;

6 - Mount Hanbegiiburun, 3 km north northeast of Geokdere.

The fossils mentioned in the descriptions of the sections were collected during the expedition carried out in October 1997.

Another section ("Geokdere"), almost 12 km north northeast of Geokdere, was sampled by one of the authors (T. N. B.) in 1959 and the most relevant data are compared with those obtained from Sections 1-6.

We must stress that despite the absence of vegetation, the shaly intervals are often covered by relatively thick (0.50 - 1 m) colluvial material. This masks the real succession and only the more calcareous, harder, beds are exposed.

All sections are described below from bottom to top.

Section 1 - This section was logged and sampled about 2 km SW of the westernmost edge of the ridge called Mount Bishik (Fig. 2). The base of this section (Fig. 3) may correspond to the top of the Urgonian facies sensu Prosorovsky (1990). Older beds crop out in the canyons located 2-3 km south of the southern flank of Mount Bishik.

Upper Barremian.

Top of the Urgonian facies - Arenaceous limestone with orbitolinids and the bivalve *Ceratostreon tuberculiferum* (Koch & Dunker).

Layer 1 - bioclastic calcareous sandstone, capped by a thin horizon containing numerous internal molds of bivalves: *Cucullaea* sp., *Trigonia carinata* Agassiz s.l., ? *Resatrix* (*Vectorbis*) *vectensis* (Forbes); 1 m
- siltstone. 2 m

Layer 2 - thin level with ? *Ceratostreon*;
- grey siltstone; the brachiopods *Belbekella multiformis* ? (Roemer) and an unidentified terebratulid were found 0.30 m below the top. 1.5 m

Layer 3 - laminated sandstone with fragments of molluscs; 0.20 m
- grey siltstone with intercalation of numerous, ferruginous, hard surfaces; echinoids referable to *Toxaster* cf. *retusus* (Lamarck) (sample SWG 3bis) at the very base; on top, "*Cardium*" aff. *cottaldinum* d'Orbigny and

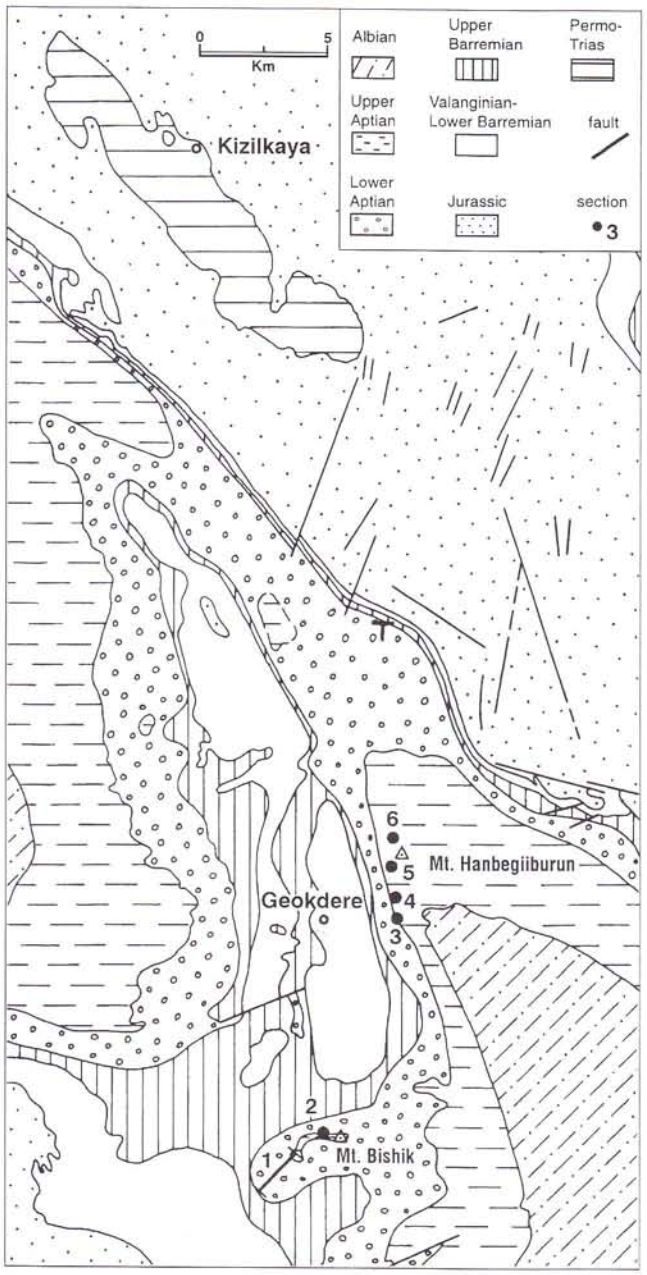


Fig. 2 - Geologic map of the study area. Letter T indicates the approximate location of Section "Geokdere".

very abundant specimens of the brachiopods *Belbekella bertheloti* (Kilian), *Sellithyris* sp.; 3.5 m
- siltstone. 4.5 m

Layer 4 - thin bivalve-rich level;
- siltstone. 1.5 m

Layer 5 - yellowish sandstone with intercalations of grey siltstone and/or finer poorly cemented sandstone; an oolitic level with fragments of molluscs on top; 8 m
- grey shale. 3.5 m

Layer 6 - composite level. From the bottom: (6a) layer of white, micritic nodules (15-25 cm long and 5-10 cm thick) dispersed in the shale; (6b) 1 m of shale capped by a hard, ferruginous surface; (6c) 1 m of shale; (6d) 7 cm thick bed of a white, micritic limestone; (6e) 0.5 m of shale capped by a thin level with the bivalves *Gervillaria alaeformis* (J. Sowerby), *Gervillella sublanceolata* (d'Orbigny), *Ceratostreon tuberculiferum* (Koch & Dunker) and gastropod specimens of *Confusiscala rhodani* (Pictet & Roux) (identified by V. A. Kotkov); 2.80 m thick
- shale. 4 m

Lower Aptian, *Deshayesites tuarkyricus* Zone.

Layer 7 - bed of hard sandstone 0.30 m thick, overlain by 0.20 m of a bioclastic, oolitic level with fragments of molluscs, echinoids, corals, the ammonites *Deshayesites antiquus* Bogdanova and *Deshayesites* sp. and the bivalve "*Iotrigonia*" *abichi* (Anthula);
- shale. 0.5 m.

Layer 8 - bed of sandstone, 0.20 m thick, overlain by a 0.20 m thick level with intraclasts, trigoniids, *Deshayesites* sp.;
- shale (1 m) capped by a hard, ferruginous surface;
- shale. 1.5 m.

Layer 9 - oolitic sandstone with intraclasts, fragments of small bivalves, rhynchonellids, *Deshayesites* cf. *antiquus* ? Bogdanova; 0.30 m.
- yellowish siltstone. 0.5 m.

Layer 10 - laminated sandstone, pinching out laterally. 0.20 m.

Sampling was terminated about 150 m before the foot of the cliff of Mount Bishik due to unfavourable outcrop conditions and was continued laterally 200 m north, just at the base of the slope of the westernmost edge of M. Bishik, starting from Layer 9.

Layer 9 - oolitic sandstone with fragments of bivalves, rhynchonellids; just a few centimetres below *Deshayesites tuarkyricus* Bogdanova and the nautiloid *Cymatoceras pseudoelegans* (d'Orbigny) were found; 0.20 m.
- yellowish siltstone. 1.80 m.

Layer 10 - sandstone containing oolites and mollusc debris; 0.20 cm.
- grey shale. 5 m.

Lower Aptian, *Deshayesites weissi* Zone.

Layer 11 - hard, ferruginous sandstone; 0.15 m.
- yellowish silty shale. 17 m.

Layer 12 - Bed of grey marl, 0.15 cm thick, with abundant *Deshayesites* specimens, unidentifiable bivalves, numerous gastropod specimens of the genus *Nummocalcar* (identified by M. A. Golovinova) and fragments of echinoid spines, followed by a bed of arenaceous limestone, 0.20 cm thick, whose upper surface is crowded by ammonites: *Deshayesites* aff. *deshayesi* (Leymerie), *D. luppovi* Bogdanova, *D.* cf. *spathi* Casey, *D.* cf. *kiliani* Casey, *D.* cf. *evolvens* Luppov;
- grey shales, 2.5 m thick, capped by a hard, arenaceous, ferruginous bed 0.10 m thick;
- grey shales, 2 m, capped with a bioturbated, hard, arenaceous surface;
- grey shales. About 2.5-3 m.

Layer 13 - 0.30 to 0.70 m of laminated sandstone forming globular bodies laterally: this level was followed on the flank of the mountain and corresponds to Layer 11 of Section 2;
- shale with belemnites and *Deshayesites pappi* Bogdanova on top. 6 m.

Layer 14 - Marls with calcareous, glauconite-coated nodules containing rare fragments of bivalves. This Layer continues in Section 2, where it has been named Layer 10.

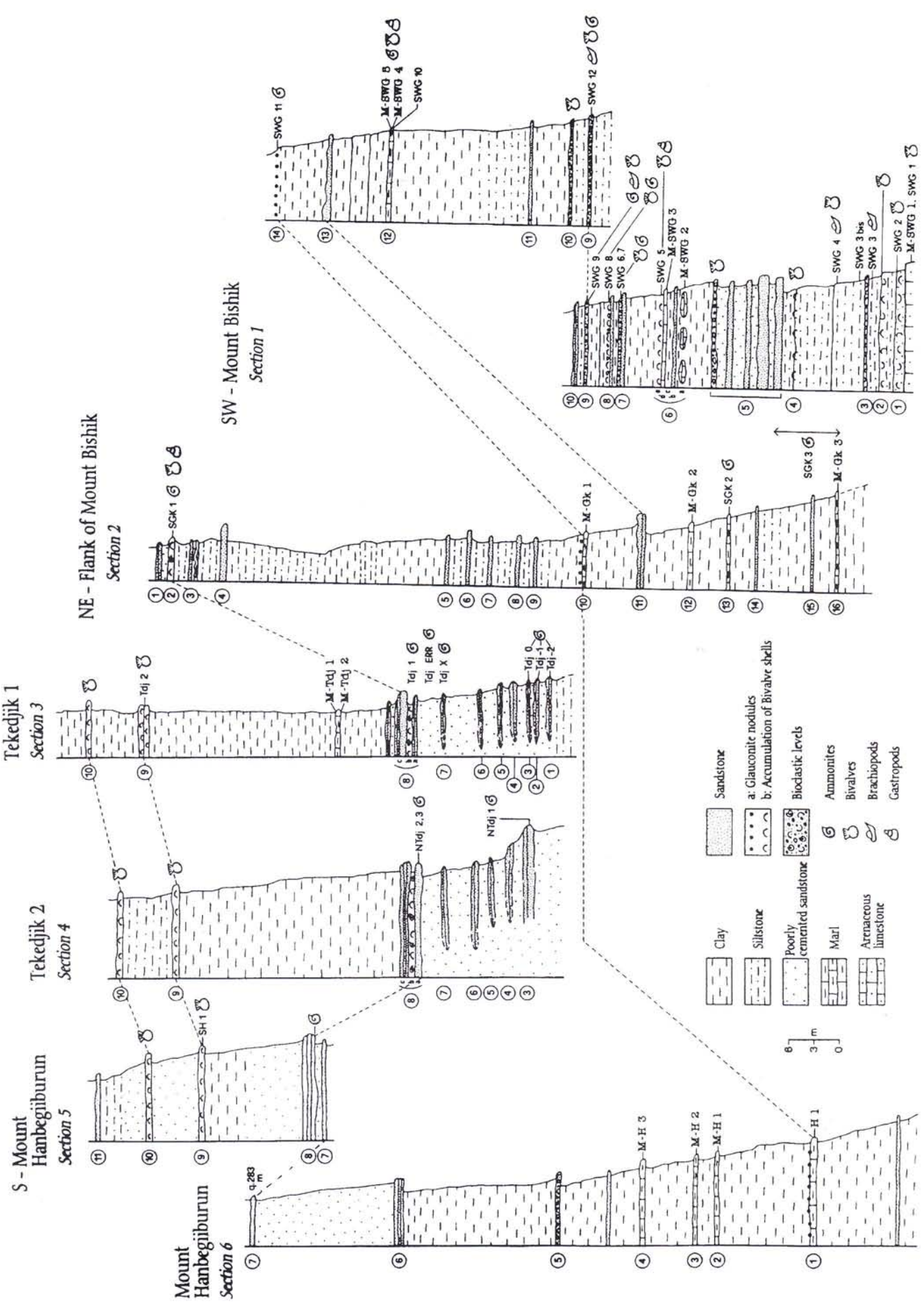
Section 2 - This section was studied on the northwestern flank of Mount Bishik (Fig. 2, 3). Its base corresponds to the shales at the foot of the cliff.

Lower Aptian, *Deshayesites weissi* Zone.

Layer 16 - limestone bed; 0.20 m.
- grey shale. 3 m.

Layer 15 - ferruginous sandstone; 0.15 m.
- shales and siltstones in the upper part; 7 m. A specimen of *Deshayesites similis* Bogdanova was collected from the talus, but it origi-

Fig. 3 - Stratigraphic logs of Sections 1-6. Encircled numbers on the left side of the logs correspond to the Layers discussed in the text, whereas numbers on the right side correspond to sample numbers.


S - Mount Hanbegiiburun
Section 5
Tekedjik 2
Section 4
Tekedjik 1
Section 3
NE - Flank of Mount Bishik
Section 2
SW - Mount Bishik
Section 1
Mount Hanbegiiburun
Section 6
SH 1
NTdj 2.3
NTdj 1
Tdj 2
M-Tdj 1
M-Tdj 2
Tdj 1
Tdj ERR
Tdj X
Tdj 0
Tdj -1
Tdj -2
SGK 1
M-Gk 1
M-Gk 2
SGK 2
SGK 3
M-Gk 3
SWG 11
M-SWG 5
M-SWG 4
SWG 10
SWG 12
SWG 9
SWG 8
SWG 6.7
SWG 5
M-SWG 3
M-SWG 2
SWG 4
SWG 3 bis
SWG 3
SWG 2
M-SWG 1. SWG 1
q 283 m
M-H 3
M-H 2
M-H 1
H 1
Clay
Sandstone
a: Glauconite nodules
b: Accumulation of Bivalve shells
Siltstone
Bioclastic levels
Poorly cemented sandstone
Ammonites
Marl
Bivalves
Arenaceous limestone
Brachiopods
Gastropods
8
3
0
m

nated from the interval between the top of Layer 16 and 4 metres above Layer 15.

Layer 14 - ferruginous sandstone; 0.15 m.
- shales. 3.5 m.

Layer 13 - Bed of grey marly limestone; 0.10-0.15 m.
- grey shale; a deshayesitid ammonite was collected from the talus. 4.5 m.

Layer 12 - Bed of grey marly limestone containing rare fragments of bivalves; 0.10-0.20 m.
- grey shale. 5.5 m.

Layer 11 - Globular bodies of sandstone (diameter of about 0.5 m) resting upon 0.20 m of a sandstone bed containing rare, small bivalves (mainly oysters); this Layer continues laterally in Section 1, where it was designated as Layer 13.
- grey shale. 6 m.

Layer 10 - Marl overlain by calcareous, glauconite-coated nodules containing rare fragments of bivalves. This Layer continues in Section 1, where it was named Layer 14.
- shale; 3 m.
- fine poorly cemented sandstone. 3 m.

A 41 m thick succession of siltstones and bioturbated sandstones follows (Fig. 3). *Thalassinoides* was observed in Layer 5 and Layer 4; it is associated with *Skolithos* in the siltstone above Layer 4.

Upper Aptian, *Epicheloniceras subnodosocostatum* Zone

Layer 3 - hard, bioturbated (*Skolithos* and *Thalassinoides*) sandstone, tending to form globular bodies; 1 m.
- yellow siltstone. 2 m.

Layer 2 - fossil-rich, arenaceous Layer containing numerous bivalves including *Aetostreon latissimum* (Lamarck), *Litschkotrigonia inguschensis* (Renngarten), *Pterotrigonia ornata* (d'Orbigny), the gastropod *Pleurotomaria* sp., the nautiloid *Cymatoceras pseudoelegans* (d'Orbigny) and the ammonites *Epicheloniceras* gr. *tschernyschewi* (Sinzow), *E.* cf. *tschernyschewi*, *E. tschernyschewi* var. *minuta* (Sinzow), *E.* cf. *subnodosocostatum* (Sinzow); 0.60 m.
- silty sandstone. 1 m.

Layer 1 - ferruginous, arenaceous concretions forming a flat morphology below the top of Mount Bishik; 0.5 m.
- shale (not studied). more than 20 m.

Section 3 - Tekedjik 1 - This section is exposed 4 km east of Geokdere, in a E-W canyon cutting through the northernmost part of the Tekedjik ridge (Fig. 2, 3). Its base consists of siltstones and shales cropping out at the foot of the ridge.

Upper Aptian, *Epicheloniceras subnodosocostatum* Zone

Layer 1 - ferruginous stratified sandstone with fragments of body chambers of *Epicheloniceras*; 0.5 m.
- sandstone. 1 m.

Layer 2 - thin, stratified, ferruginous, bioturbated sandstone with *Epicheloniceras tschernyschewi* var. *minuta* (Sinzow); 0.80 m.
- sandstone; 0.60 m.

Layer 3 - stratified ferruginous sandstone with *Caspianites* cf. *tuarkyriensis* Kakabadze, *Epicheloniceras* cf. *tschernyschewi*? var. *minuta*? (Sinzow). 0.60 m.
sandstones and stratified ferruginous sandstones (Fig. 3). 10 m.

Layer 7 - stratified ferruginous sandstone with *Epicheloniceras* cf. *buxtorfi* (Jacob); *Caspianites tuarkyriensis* Kakabadze was collected from the talus but it probably originated from the overlying Layer 8b; 0.5 m.
- sandstone. 3 m.

Layer 8 - Composite fossil-rich level. 3 m. From the bottom:
8a, layer of hard sandstone, containing fragments of oysters and small specimens of *Epicheloniceras*, 0.70 m, capped by a thin shelly horizon with fragments of small bivalves;
8b, sandstone with giant, resedimented and reelaborated (both terms sensu Fernandez Lopez, 1991) ammonite specimens of *Epicheloniceras* gr. *tschernyschewi* (Sinzow) which are concentrated at the base and *E. subnodosocostatum* var. *robusta* (Sinzow); 0.70 m. This deposit is discontinuously overlain by a lenticular bioclastic, bivalve-rich Layer with *Gervillella sublanceolata* (d'Orbigny), *Aetostreon latissimum* (Lamarck), *Litschkotrigonia inguschensis* (Renngarten), *Pterotrigonia ornata* (d'Orbigny), *Thetis minor* (J. de C. Sowerby), "*Astarte*" *karajmanica* Prosorovsky, unidentified pectinids and heterodonts, *Belbekella* sp. and wood debris; vertical fossil traces (*Skolithos* ?) are visible in the upper part;
8c, hard, bioturbated sandstone, with bivalve fragments. 1.60 m.
- sandstone; 1 m.
- stratified ferruginous sandstone; 0.5 m.
- grey shales, mainly covered by colluvium; 35 m. Under this cover, 6 m above the arenaceous concretions millimetric, black-white marly alternances overlain by a bed of marly limestone, 0.20 m thick, were observed.

Layer 9 - thick monospecific coquina with *Aetostreon latissimum* (Lamarck); 1.5 m.
- grey to yellowish siltstones. 6 m.

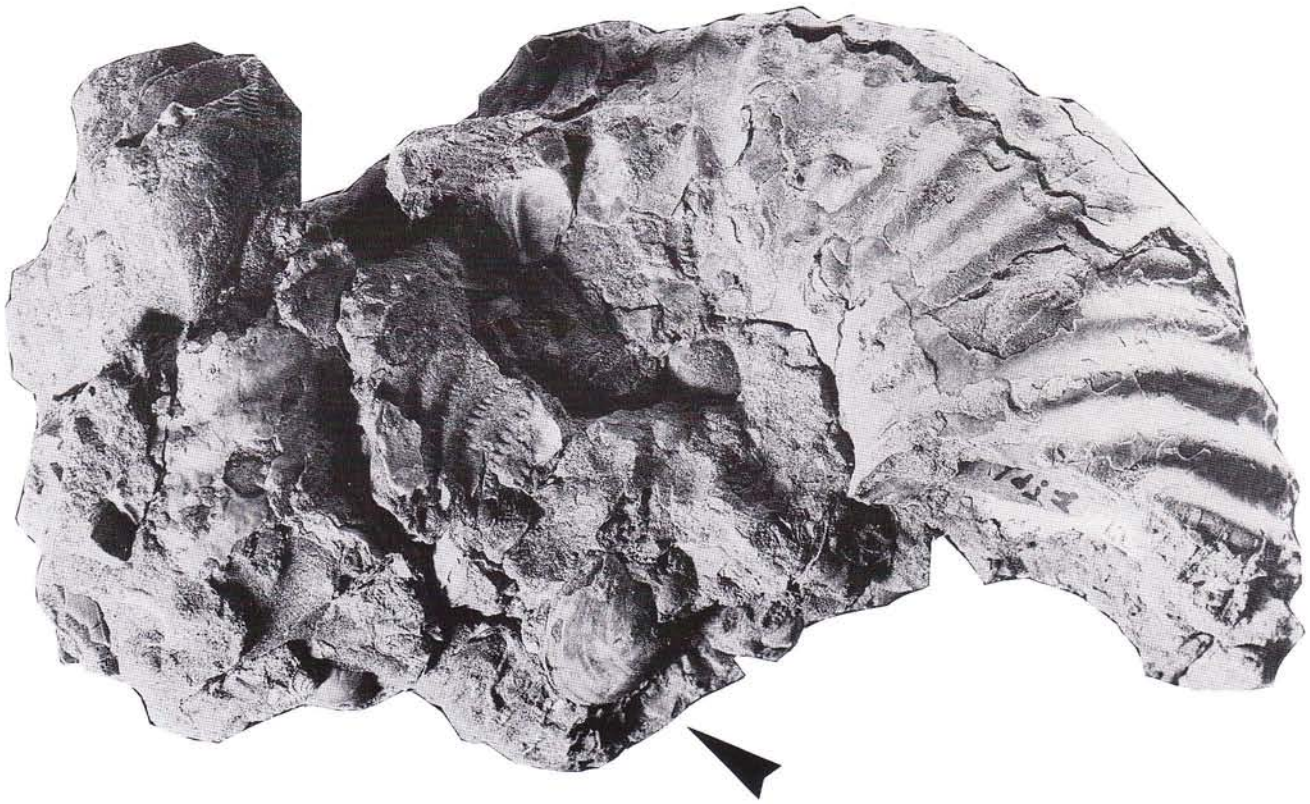


Fig. 4 - Bottom side of a fragmentary specimen of *Epicheloniceras* gr. *tschernyschewi* (Sinzow) showing bivalve encrustations. The arrow indicates a juvenile oyster shell encrusting a broken part of the shell. Specimen MPUM 8274, housed in the Museo di Paleontologia of the University of Milan.

Layer 10 - thick monospecific coquina with oyster shells (not sampled); 0.5 m.
- siltstones (not studied). about 50 m.

Section 4 - Tekedjik 2 - This section is located about 1 km north of Section 3 (Fig. 2) and it shows a similar succession. Thus, the same Layer-numbering was used. The section starts with the equivalent of Layer 3 of Section 3 (Fig. 3).

Upper Aptian, *Epicheloniceras subnodosocostatum* Zone

Layer 3 - stratified ferruginous sandstone with the ammonite *Epicheloniceras* gr. *tschernyschewi* (Sinzow). 0.60 m.
An 11 m thick succession of sandstones and stratified ferruginous sandstones follows (Fig. 3).

Layer 8 - In this section, this Layer is 2.4 m thick. From bottom to top:
layer 8a shows the same characteristics as in Section 3;
8b, sands with the same fossil content of Section 3 plus the bivalves *Aetostreon latissimum* (Lamarck) and *"Astarte" karajmanica* Prosorovsky; 0.60 m.
8c, hard, bioturbated sandstone; 0.90 m.
- grey shale. about 30 m.

Layer 9 - monospecific coquina with *Aetostreon latissimum* (Lamarck); 0.7 m.
- fine siltstone. 6 m.

Layer 10 - monospecific coquina with oyster shells. 0.5 m.

Remarks on Layer 8 in Sections 3 and 4.

This composite level is characterized by the presence of giant *Epicheloniceras* gr. *tschernischewi* (Sinzow) resembling the largest specimens illustrated by Nikchitch (1915). It must be stressed that the collection of ammonites from Layer 8 in both Sections 3 and 4 had to be limited for practical reasons. The preservation of the specimens from this Layer (and its lateral equivalents) is not satisfactory, because the young whorls are poorly preserved or absent. The characteristics of the young whorls are necessary for species identification (Casey, 1960-80) and in the future a more detailed palaeontological study of these giant forms of *Epicheloniceras* should be based on larger collections, seeking with care specimens with better preserved inner whorls.

The faunal content as well as the taphonomic characteristics, indicate that high energy was required to transport and break the bivalve shells in layer 8a. However, even higher energy is necessary to explain the re-elaboration of the giant (40-45 cm diameter) specimens of *Epicheloniceras*. The term re-elaboration (or taphonomic reworking), meaning the exhumation and dis-

Fig. 5 - Upper side of the same specimen of fig. 4. The arrow indicates both an external and an internal mold of two bivalves resting on the elaborated upper side of the ammonite internal mold.

placement of previously buried preserved elements, is used here according to Fernandez Lopez (1991). Generally, these specimens are incomplete with the body-chamber missing. Fragments of body-chambers of specimens that probably reached a diameter of 50-55 cm are common in layer 8b. We observed oysters attached to both sides of some of these ammonite specimens (Fig. 4, 5). However, the hypothesis that encrustation occured during both the life-cycle (Seilacher, 1960; Donovan, 1989) and post-mortem floating of the empty shell may be excluded since oysters settled also on the corners of the broken shell (Fig. 4). This observation also excludes Cope's (1968) hypothesis of encrustation of the undersurface of dead ammonites which were resting on the substrate.

Due to the weight of such large specimens, the energy necessary for re-elaboration was very high. Figs. 4 and 5 show these characteristics on a smaller fragment from a specimen of *Epicheloniceras* cf. *tschernyschewi* that we could transport from the field.

The succession of the different taphonomic phases can be summarized as follows:

1) accumulation of the fragmented ammonite shells on the bottom;

2) bivalves' settlement;

3) burying of ammonite shells;

4) compaction and beginning of lithification of the ammonite's internal mold;

5) re-exhumation and overturning of the ammonite shells;

6) erosion of the other face followed by encrustation of a second oyster community.

It is worth noting that trigoniids are not broken and the two valves are often connected. Therefore they are not reworked.

Section 5 - This short section connects Section 4 and Section 6 and it was logged about 1.5 km south of the latter (Fig. 2, 3).

Upper Aptian, *Epicheloniceras subnodosocostatum* Zone

Layer 7 - reddish, stratified ferruginous sandstone; this Layer was followed for 1.5 km and corresponds to Layer 7 of Section 6; 0.30 m.
- poorly cemented sandstone. 1 m.

Layer 8 - hard, ferruginous, bioturbated sandstone with giant *Epicheloniceras* spp.; 2 m.
- poorly cemented sandstone. 12 m.

Layer 9 - monospecific coquina with *Aetostreon latissimum* (Lamarck); it is the lateral continuation of Layer 9 of section 4; 0.5 m.
- fine, poorly cemented sandstone. 6 m.

Layer 10 - oyster coquina (lateral continuation of Layer 10 of Section 4); 0.5 m.
- fine, poorly cemented sandstone to siltstone. 6 m.

Layer 11 - hard sandstone. 0.5 m.

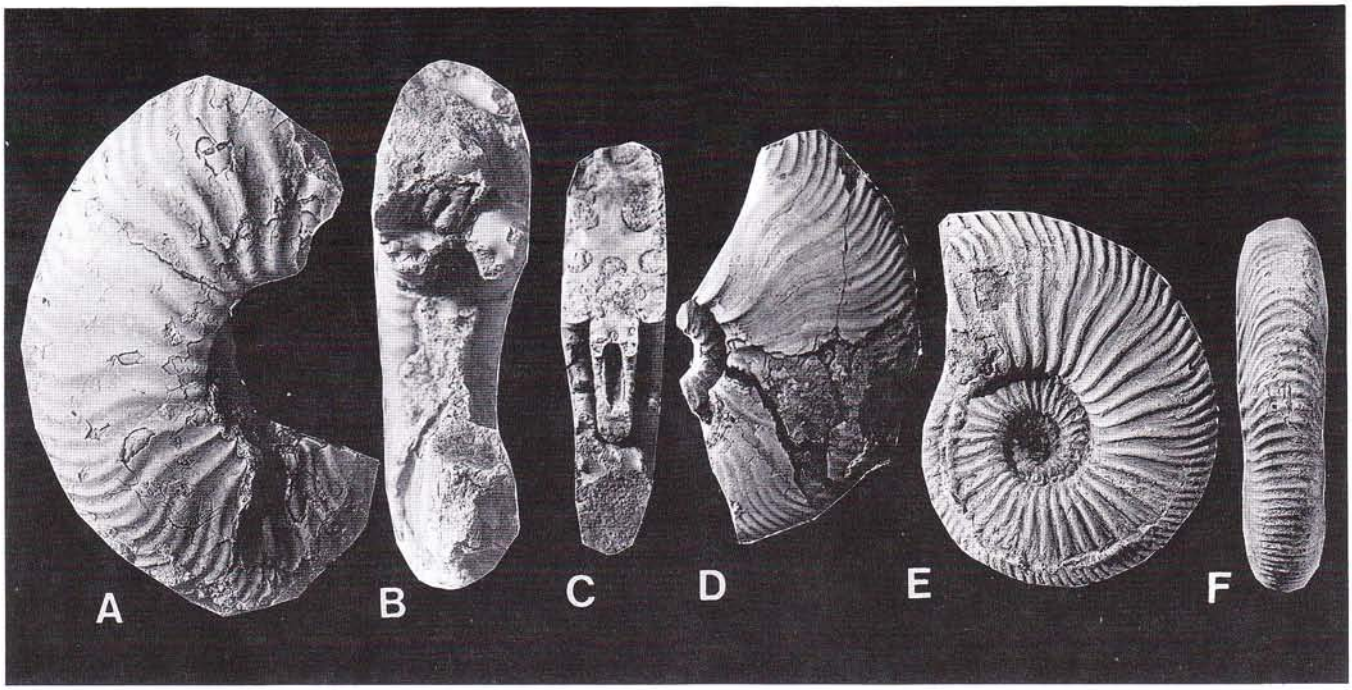


Fig. 6 - Significant ammonites from Section "Geokdere". *Deshayesites* aff. *antiquus* Bogdanova, 1983: A) lateral view, B) frontal view, Layer 9, specimen 45/9442, x1. *Deshayesites tuarkyricus* Bogdanova, 1983: C) frontal view, D) lateral view, Layer 9, specimen 4/9442, x1. Holotype of *Turkmeniceras geokderense* Tovbina, 1963: E) lateral view, F) ventral view, Layer 4, specimen 7/8293, x1. All specimens are housed in the F. N. Chernychev Central Scientific-Research Geological Exploration Museum (CNIGR).

Section 6 - This section was logged 1.5 km north of Section 5 and corresponds to the cliff of Mount Hanbegiiburun, whose top is at 283 m (Fig. 2). The base of the section corresponds to siltstones and shales at the foot of the cliff (Fig. 3).

- sandstone; 0.30 cm.
- grey to yellowish shale. 10 m.

Layer 1 - marl overlain by calcareous, glauconitic nodules containing some rare fragments of ? *Limaria* aff. *parallela* (J. Sowerby), *Thetis minor* (J. de C. Sowerby) and brachiopods; 0.70 m.

A 21 m thick succession of shales and marls with ferruginous surfaces follows (Fig. 3).

Layer 5 - bed of arenaceous pebbles containing fragments of bivalves (trigoniids, pectinaceans) overlain by large oysters; 0.20 m.

- shale. 19 m.

Layer 6 - sandstones with fine debris of mollusc shells, capped by a hard ground with *Thalassinoides*; 1 m.

- yellowish, fine poorly cemented sandstone. 17 m.

Layer 7 - reddish, stratified ferruginous sandstone that was followed for 1.5 km up to Section 5. 0.30 m.

Section "Geokdere" - In 1959 one of the authors (T. N. B.) sampled a section located about 10 km north of Section 6 (indicated with "T" in Fig. 2), which was called "Geokdere". This section provides complementary information because upper Barremian ammonitiferous beds were discovered. Some significant ammonites are reproduced in Fig. 6.

The ammonites *Imerites favrei* Rouchadze and *Imerites giraudi* var. *multicostata* Tovbina were found in Layer 1, a 0.10 m thick bioclastic layer belonging to the *Imerites* and *Colchidites* beds, that can be correlated to the *Imerites giraudi* Zone of the Mediterranean zonation (Hoedemaeker & Company, 1993).

Layer 1 is overlain by 6.6 m of poorly cemented sandstone.

Layer 4 is also a 0.20 m thick, bioclastic layer in which *Turkmeniceras geokderense* Tovbina (Fig. 6 E, F), *T. turkmenicum* Tovbina, *T. multicostatum* Tovbina and *T. rarecostatum* Bogdanova were found. This assemblage indicates the *Turkmeniceras turkmenicum* Zone, which is currently ascribed to the uppermost Barremian (Bogdanova & Tovbina, 1995), although no direct correlations with the Mediterranean areas exist. In fact, *Turkmeniceras* is reported only in Turkmenia and Caucasus and is not associated with other taxa that could allow correlations.

About 22 m of poorly cemented sandstone follow, capped by bioclastic Layer 9, 0.40 m thick. It contains *Deshayesites tuarkyricus* (Fig. 6 C, D), *D. weissiformis* Bogdanova, *D.* aff. *antiquus* (Fig. 6 A, B) and *D.* sp. This assemblage clearly indicates the Early Aptian *D. tuarkyricus* Zone.

It is followed by 5.4 m of silty, poorly cemented sandstone that is overlain by bioclastic Layer 11 which also contains ammonites of the *D. tuarkyricus* Zone: *D. tuarkyricus*, *D. antiquus*, *D.* sp.

Layer 11 is overlain by 13 m of sandstone, followed by 10 m of silty clay, 5.5 m of clayey sandstone and 17 m of clay and silty clay. This in turn is overlain by arenaceous, bioclastic Layer 18 in which ammonites of the *D. weissi* Zone were found (*D. weissi*, *D. consobrinus* (d'Orbigny) sensu Bogdanova (1983) and *D. deshayesi*). This last Layer is overlain by 8 m of siltsone and clayey siltstone, tentatively ascribed to the *D. deshayesi* Zone. The marker Layer with calcareous, glauconite coated nodules then occurs(Layer 20). This marker Layer was recognized as Layer 14 in Section 1, Layer 10 in Section 2 and Layer 1 in Section 6. Interestingly, in the "Geokdere" section the marker Layer is overlain by 4.7 m of poorly cemented sandstone which contain ammonites of the *Dufrenoya furcata* Zone at the top: *Dufrenoya dufrenoyi* (d'Orbigny), *D. fursovae* Bogdanova, *Cheloniceras cornuelianum* (d'Orbigny), *C. cornuelianum* var. *pygmaea* Nikchitch, *C. seminodosum* (Sinzow), *C. meyendorfi* (d'Orbigny) and *Ancyloceras rochi* Casey.

The section continues with more than 70 metres of clay, sandstone and siltstone with only two fossiliferous bivalve beds. It is worth noting that in this section no lateral equivalents of the *Epicheloniceras* beds (e. g. Layer 8 in Sections 3 and 4) and coquinas with *Aetostreon latissimum* (Layers 9 and 10 of sections 3 and 4) exist.

Bivalve fauna.

Bivalve faunas from these regions were studied previously by Bogdanova (1961; 1966) and Prosorovsky (in Prosorovsky et al., 1961).

The bivalve faunule studied was poorly preserved with the heterodont taxa particularly difficult to identify at the species level.

The fauna studied herein consists mainly of Bakevelliidae [*Gervillaria alaeformis* (J. Sowerby) and *Gervillella sublanceolata* (d'Orbigny)], of exogyrine oysters [*Aetostreon latissimum* (Lamarck) and *Ceratostreon tuberculiferum* (Koch & Dunker)] and of Trigoniidae [*Trigonia carinata* s.l., *"Iotrigonia" abichi* (Anthula), *Litschkotrigonia inguschensis* (Renngarten) and *Pterotrigonia ornata* (d'Orbigny)].

Furthermore, one unidentified *Cucullaea* sp., one limid [? *Limaria* aff. *parallela* (J. Sowerby)], one large astartid (*"Astarte" karajmanica* Prosorovsky), one possible mactromyid [*Thetis minor* (J. de C. Sowerby)], one cardiid (*"Cardium"* aff. *cottaldinum* d'Orbigny) and a few other heterodonts, mainly unidentified, were found.

Palaeoecological considerations - The taxa identified at species level indicate a shallow, fairly warm and fully marine environment, typical for the Tethyan Lower Cretaceous (Dhondt & Dieni, 1989; Dhondt, 1992).

The trigoniids were sometimes found with both valves and can be assumed to have been collected in life position. If Stanley's interpretation for such trigoniids (Stanley, 1977; 1978) is followed, they lived in "nearshore habitats of Early Cretaceous Tethyan seas at water depths no greater than 10 - 15 m " (Stanley, 1978).

Bakevelliid specimens were also found occasionally with both valves. Bakevelliidae were suspension-feeders and were assumed to be byssate epifaunal forms (Muster, 1995, p. 6, p. 98). However, Muster, in her discussion of the life position in several bakevelliid genera (1995, p. 98-99) considered *Gervillaria alaeformis* as byssally attached to a hard particle in the sediment, but with the umbonal valve partially sunken into the sediment -making the taxon close to being a recliner. For the genus *Gervillella* she suggested a mudsticker life position (see also Fürsich, 1977; Seilacher, 1984); shells of *Gervillella sublanceolata* would thus have spent most of their life sticking in the sediment (see also Stanley, 1972, p. 187, fig. 19 C).

Exogyrine oysters are epifaunal recliners (cup shaped recliners in Seilacher, 1984) or cemented forms. The large *Aetostreon latissimum* was certainly a recliner, commonly with oyster spat on the convex valve. The fairly small *Ceratostreon tuberculiferum* can be considered an opportunistic species, [as *Nanogyra virgula* in the uppermost Jurassic (Fürsich, 1977)].

Trigoniids are very shallow burrowers (Stanley, 1978). None of the other taxa known from Tuarkyr indicate deep burrowing. Even *"Astarte" karajmanica* was probably a shallow burrower [for recent, smaller *Astarte* taxa Stanley (1970) indicates a preference for sand - both fine and coarse - and a maximum depth of 35 m].

Most taxa collected from Tuarkyr were typical for sandy, often fairly coarse substrata.

If we consider the distribution of the fauna, in the basal Aptian (Section 1, Layers 7 and 10, samples SWG 7, 10) and in the Lower Aptian (Section 6, Layer 1, sample H1) only a few taxa were identified because of both poor preservation and low frequency. Definitive conclusions are difficult to draw on the basis of the relatively small faunal sample available. The complete absence of trigoniids in sample H1 may be considered an indication that in this bed ? *Limaria* aff. *parallela* and *Thetis minor* lived in less shallow environments than the faunas from the Upper Barremian or Upper Aptian.

Palaeobiogeographic considerations - Some of the taxa had a very wide tethyan distribution (the bakevelliids and the oysters, and two of the trigoniids are found from the west coast of South America to Central Asia, and *Gervillaria alaeformis* even reached Japan) (Dhondt & Dieni, 1988). Two trigoniids [*Litschkotrigonia*

	Isle of Wight Lower Aptian	Section 1 Levels 0-6 Upper Barremian	Section 1 Levels 7-12 Basal Aptian	Section 6 Level 1 Lower Aptian	Sections 3,4 Level 8 Upper Aptian	Section 2 Level 2 Upper Aptian	Sections 3,5 Level 9 Upper Aptian
Gervillaria alaeformis	+	+					
Gervillella sublanceolata	+	+			+		
? Limaria cf. parallela	+			+			
Aetostreon latissimum	+				+	+	+
Ceratostreon tuberculiferum	+	+					
Trigonia carinata	+	+					
"Iotrigonia" abichi			+				
Litschkotrigonia inguschensis					+	+	
Pterotrigonia ornata	+				+	+	
Thetis minor	+			+	+		
Astarte karajmanica					+		
Cardium aff. *cottaldinum*	+	+					
? Resatrix vectensis	+	+					

Tab 1 - Comparison between Aptian bivalve faunas from the Isle of Wight and those from Tuarkyr.

inguschensis (Renngarten) and *Iotrigonia abichi* (Anthula)] are known from the Caucasus, from Mangyshlak and from Turkmenistan. *Litschkotrigonia inguschensis* has undoubtedly evolved from *Quadratotrigonia nodosa* (J. de C. Sowerby) which has a much wider geographic distribution. Many taxa are comparable (Table 1) to Aptian faunas from the Isle of Wight (Woods 1899 - 1913). However, due to intensive collecting over almost two-hundred years, the faunas of the latter locality are amongst the best known Cretaceous faunas and therefore diversity of the coeval Tuarkyr faunas cannot be judged with the same criteria. Research in Tuarkyr started relatively recently and both natural and logistic difficulties in accessing the outcrops have limited the extent of data collection compared to the Isle of Wight.

Ammonite biostritigraphy.

Due to the natural exposure of the succession along cuestas devoid of any vegetal cover, we were able to follow the different stratigraphic Layers and to check the correlation between the different sections studied.

The faunas sampled do not have a continuous stratigraphic distribution in the sections but are concentrated in relatively few fossiliferous beds.

Deshayesites tuarkyricus Zone - The older Layers sampled are located at the base of Section 1. Because no ammonites were found, these rocks are assigned to the uppermost Barremian on the basis of the literature. The entry of the genus *Deshayesites*, marking the base of the Aptian, was recorded in layer 7 with the species *Deshayesites antiquus* Bogdanova which indicates the *D. tuarkyricus* Zone (Bogdanova, 1971a, 1979, 1983; Bogdanova & Tovbina 1995; Bogdanova & Prosorovsky, in print). The marker species was found higher in the section, in Layer 9, and seems to postdate *D. antiquus*. A similar distribution is described by Bogdanova & Prosorovsky (in print) in the section "Utuludzha" (located west of Tuarkyr, in the Greater Balkhan Range) where *D. tuarkyricus* was found in a bioclastic bed located stratigraphically 50 m above a bed with *Deshayesites oglanlensis* Bogdanova, *D. antiquus* and *D.* aff. *antiquus*. On the other hand, Bogdanova & Prosorovsky (in print) collected *D. antiquus* and *D. tuarkyricus* from the same bed in a section located in southernmost Tuarkyr, in the southernmost part of the Tekedjik ridge, and in Layer 11 of section "Geokdere", whereas *D.* aff. *antiquus* and *D. tuarkyricus* co-occur in Layer 9. It is very difficult to determine whether or not *D. antiquus* really predates *D. tuarkyricus*. In fact, the ammonite-bearing bioclastic beds probably correspond to lenses with a restricted lateral extent which does not allow a fine bed by bed correlation.

Deshayesites weissi Zone - *Deshayesites similis* Bogdanova indicates the beginning of the second ammonite Zone of the Aptian, the *Deshayesites weissi* Zone. This species was found in Section 2, which corresponds to the same succession exposed in Section 1 but located along the northern flank of Mount Bishik. Though this ammonite was collected from the talus, in the field it was clear that it must have come from the interval between the top of Layer 16 and 4 metres above Layer 15. In Section 1, the bed that contained the speci-

men of *D. similis* might be located within the interval from 6 to 12 metres above the bed where *D. tuarkyricus* was found. In Layer 12 of Section 1 a rich, although poorly preserved, ammonite fauna was found. The species identified are usually reported both by Casey (1961) and Bogdanova (1971a) from the *D. weissi* Zone: *D. luppovi* Bogdanova, *D.* cf. *spathi* Casey, *D.* cf. *kiliani* Casey, *D.* cf. *evolvens* Luppov. However, some specimens show morphologic affinities with *D. deshayesi* and were identified provisionally as *D.* aff. *deshayesi* (see pl. 1, fig. 6). These specimens resemble the ammonites from the *D. weissi* Zone illustrated as *D. dechyi* (Papp) by Bogdanova (1977, pl. 2, fig. 1, 2) but subsequently ascribed to *D. mikhailovae* Bogdanova, Kvantaliani & Sharikadze (Bogdanova et al., 1979). In any case, *D. deshayesi* is the marker of the third zone of the Aptian. According to Bogdanova (1971a) and Bogdanova & Tovbina (1995), the FO of *D. deshayesi* is reported from the upper part of the *D. weissi* Zone, though this was not observed in Kopet Dag and other Transcaspian areas (Bogdanova, 1978; Tovbina et al., 1985). Unlike in England (Casey, 1961), in Transcaspia the base of the *D. deshayesi* Zone is characterized by the disappearance of some species and not by the FO of the index species. On the other hand, the Russian authors correlate the base of the Transcaspian *D. deshayesi* Zone with the lower part of the same Zone in England (i. e. with the *Cheloniceras parinodum* Subzone), though the specific compositions of the faunal assemblage is different. Thus, the problem of the precise correlation between the English and Turkmenian *D. deshayesi* Zones is not yet resolved because *D. weissi* is lacking in England. Probably the vertical range of the English *Deshayesites forbesi* Zone does not match exactly that of the Transcaspian *D. weissi* Zone. In this connection a deep palaeontologic revision of the species *D. deshayesi* is also recommended.

Deshayesites deshayesi Zone - This zone was not recognized. Fourteen metres above Layer 12 of Section 1 the marker Layer with glauconite-coated nodules (Layer 14) occurs. A specimen of *D. pappi* Bogdanova, indicative of the *D. weissi* Zone (Bogdanova, 1971a; Bogdanova & Tovbina, 1995), was found just below the nodular interval. In section "Geokdere", an 8 m thick interval of unfossiliferous siltstones and clayey siltstones, underlying the marker Layer, was tentatively ascribed to this zone.

Dufrenoyia furcata Zone - The Layer with glauconite-coated nodules was recognized in Section 2 (here named Layer 10), almost 15 km north in Section 6 (Layer 1) and 25 km north of Section 2 in Section "Geokdere" (boundary between Layers 19 and 20). It may be used as a local marker Layer that probably is incorporated in the gap mentioned by the Russian authors (Resolution of the Interdepartamental Stratigraphic Commission, Samarkand, 1977; Bogdanova & Tovbina, 1995) and that probably encompasses the interval occupied by the *D. deshayesites* Zone and the lower part of the *Dufrenoyia furcata* Zone. The latter zone was recognized only in Layer 20 of Section "Geokdere", above the glauconitic marker Layer. However, Bogdanova & Prosorovski (in print) found ammonites of the *D. furcata* Zone within this glauconitic marker Layer in the southern Tekedjik (southernmost Tuarkyr) and the Greater Balkhan.

Epicheloniceras subnodosocostatum Zone - Ammonites of this zone occur in Layer 2 of Section 2. This

PLATE 1

Fig. 1 - *Deshayesites antiquus* Bogdanova, 1983. Tuarkyr, Section 1, Layer 7, Early Aptian *Deshayesites tuarkyricus* Zone. Specimen MPUM 8282, x1.

Fig. 2 - *Deshayesites tuarkyricus* Bogdanova, 1983. Tuarkyr, Section 1, Layer 9, Early Aptian *Deshayesites tuarkyricus* Zone. Specimen MPUM 8289/1, x1. Fragment of the body chamber.

Fig. 3 - *Deshayesites* cf. *spathi* Casey, 1964. Tuarkyr, Section 1, Layer 12, Early Aptian *Deshayesites weissi* Zone. Specimen MPUM 8285/1, x1.

Fig. 4 - *Deshayesites similis* Bogdanova. Tuarkyr, Section 2, from an interval between the top of Layer 16 and 4 metres above Layer 15, Early Aptian *Deshayesites weissi* Zone. Specimen MPUM 8280, x1.

Fig. 5 - *Caspianites tuarkyriensis* Kakabadze, 1981. Tuarkyr, Section 3, Layer 7 collected from the talus but probably coming from Layer 8b, Late Aptian *Epicheloniceras subnodosocostatum* Zone. Specimen MPUM 8328, x1.

Fig. 6 - *Deshayesites* aff. *deshayesi* (Leymerie, 1841). Tuarkyr, Section 1, Layer 12, Early Aptian *Deshayesites weissi* Zone. Specimen MPUM 8293, x1. Totally septated specimen.

Fig. 7 - *Deshayesites pappi* Bogdanova, 1991. Tuarkyr, Section 1, top of Layer 13, Early Aptian *Deshayesites weissi* Zone. Specimen MPUM 8290, x1.

Fig. 8 - *Deshayesites luppovi* Bogdanova, 1983. Tuarkyr, Section 1, Layer 12, Early Aptian *Deshayesites weissi* Zone. Specimen MPUM 8292, x1. Totally septated specimen.

Fig. 9 - *Epicheloniceras subnodosocostatum* var. *robusta* (Sinzow, 1906): 9a ventral view; 9b, lateral view. Tuarkyr, Section 3, Layer 8b, Late Aptian *Epicheloniceras subnodosocostatum* zone. Specimen MPUM 8294 x1.

Fig. 10 - *Epicheloniceras* cf. *buxtorfi* (Jacob, 1906). Tuarkyr, Section 3, Layer 7, Late Aptian *Epicheloniceras subnodosocostatum* Zone. Specimen MPUM 8297, x1.

The arrow indicates the end of the phragmocone, where visible.
All of the material is housed in the Museo di Paleontologia of the University of Milan.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is the first ammonitiferous bed recognized above the marker Layer with glauconite-coated nodules. However, ammonites of the same zone were found in Sections 3 and 4 below Layer 8, which is the lateral equivalent of Layer 2 in Section 2; among them a specimen of *Epicheloniceras* cf. *buxtorfi* (Jacob) in Layer 7 of Section 3. In England this species occurs in the upper part of the *Epicheloniceras martinioides* Zone (the equivalent of the *E. subnodosocostatum* Zone), in the *Epicheloniceras buxtorfi* Subzone (Casey, 1961). Therefore, these *Epicheloniceras* - bearing beds correspond to the upper part of the English *E. martinioides* Zone. In the Tuarkyr area at least, the chronologic equivalence between the *E. subnodosocostatum* and the *E. martinioides* Zones (Bogdanova & Tovbina, 1995) seems to be questionable. Accordingly, in the Tuarkyr the genus *Caspianites* occurs in Layers that are younger than in England, where it disappears in the middle of the *E. martinioides* Zone, i. e. the *Epicheloniceras gracile* Subzone (Casey et al., 1998).

Conclusions.

New, detailed, stratigraphic data on the vertical distribution of both ammonite and bivalve faunas were obtained during the expedition in the southern Tuarkyr through bed by bed description of six sections spanning the interval from the uppermost Barremian to the first ammonite-zone of the upper Aptian. The integration of these new data with complementary data from section "Geokdere" allows us to improve the knowledge of the Aptian stratigraphy of the Tuarkyr.

Both ammonite and bivalve faunas have a scanty, discontinuous distribution within the lithologic successions. Most of the ammonitiferous beds recognized correspond to bioclastic lenses that do not correlate with each other. The ammonite faunas generally show low diversity; only the genus *Deshayesites* was found in the lower Aptian whereas *Epicheloniceras* and *Caspianites* characterize the layers of the basal upper Aptian. However, southwards in both southernmost Tuarkyr and the Greater Balkhan the faunas are slightly more diverse: deshayesitids are always dominant but *Phyllopachyceras*, *Protetragonites*, *Pseudohaploceras*, *Pseudosaynella*, *Toxoceratoides* and *Cheloniceras* (*C.*) occur in Lower Aptian strata. The species *Deshayesites spathi* and *Epicheloniceras buxtorfi* are reported for the first time from Turkmenistan.

The range of the Turkmenian *E. subnodosocostatum* Zone does not seem to correspond to the entire

PLATE 2

Fig. 1 - *Epicheloniceras* gr. *tschernyschewi* (Sinzow, 1906). Tuarkyr, Section 3, Layer 8b, Late Aptian *Epicheloniceras subnodosocostatum* Zone. Specimen MPUM 8272/2, x1. Totally septated specimen.

The specimen is housed in the Museo di Paleontologia of the University of Milan.

PLATE 3

Fig. 1 - *Epicheloniceras* gr. *tschernyschewi* (Sinzow, 1906). Tuarkyr, Section 4, Layer 3, Late Aptian *Epicheloniceras subnodosocostatum* Zone. Specimen MPUM 8273, x1. Totally septated specimen.

Fig. 2 - *Litschkotrigonia inguschensis* (Renngarten, 1926): left valve, composite mold. Tuarkyr, Section 3, Layer 8b, Late Aptian *Epicheloniceras subnodosocostatum* Zone. Specimen MPUM 8317/1, x 3/4.

Fig. 3 - *"Iotrigonia" abichi* (Anthula, 1899): right valve. Tuarkyr, Section 1, Layer 7, Early Aptian *Deshayesites tuarkyricus* Zone. Specimen MPUM 8309/1, x 1.5.

All of the material is housed in the Museo di Paleontologia of the University of Milan.

PLATE 4

Fig. 1 - *Gervillella sublanceolata* (d'Orbigny, 1850): 1a, fragment of right valve; 1b, fragment of right valve, inside. Tuarkyr, Section 1, Layer 6, uppermost Barremian. Specimen MPUM 8307/1, x 1.

Fig. 2 - *Gervillella sublanceolata* (d'Orbigny, 1850): 2a, fragment of right valve; 2b, fragment of left valve, inside. Tuarkyr, Section 1, Layer 6, uppermost Barremian. Specimen MPUM 8307/2, x 1.

Fig. 3 - *Aetostreon latissimum* (Lamarck, 1801): left valve. Tuarkyr, Section 3, Layer 8b, Late Aptian *Epicheloniceras subnodosocostatum* Zone. Specimen MPUM 8315/1, x 1/2.

Fig. 4 - *Aetostreon latissimum* (Lamarck, 1801): right valve, Tuarkyr, Section 3, Layer 8b, Late Aptian *Epicheloniceras subnodosocostatum* Zone. Specimen MPUM 8315/2, x 1/2.

Fig. 5 - *Ceratostreon tuberculiferum* (Koch & Dunker, 1837); left valve; Tuarkyr, Section 1, top of the Urgonian facies (sample SWG 1), Upper Barremian. Specimen MPUM 8301/1, x 2.

Fig. 6 - *"Astarte" karajmanica* Prosorovsky, 1961: right valve. Tuarkyr, Section 3, Layer 8b, Late Aptian *Epicheloniceras subnodosocostatum* Zone. Specimen MPUM 8320, x 1.5.

Fig. 7 - *Pterotrigonia ornata* (d'Orbigny, 1844): right valve; Tuarkyr, Section 2, Layer 2, Late Aptian *Epicheloniceras subnodosocostatum* Zone. Specimen MPUM 8326, x 2.5

All of the material is housed in the Museo di Paleontologia of the University of Milan.


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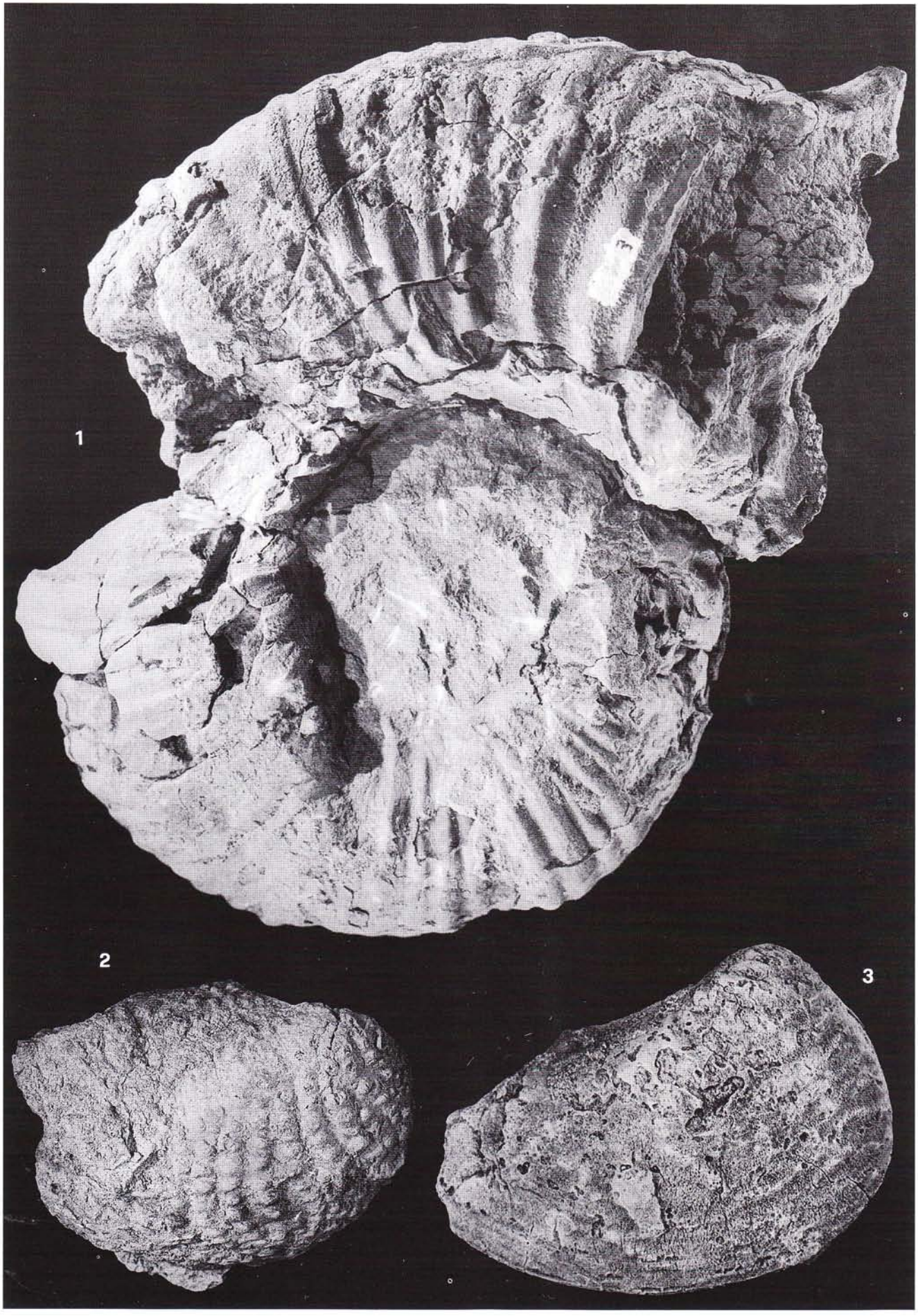
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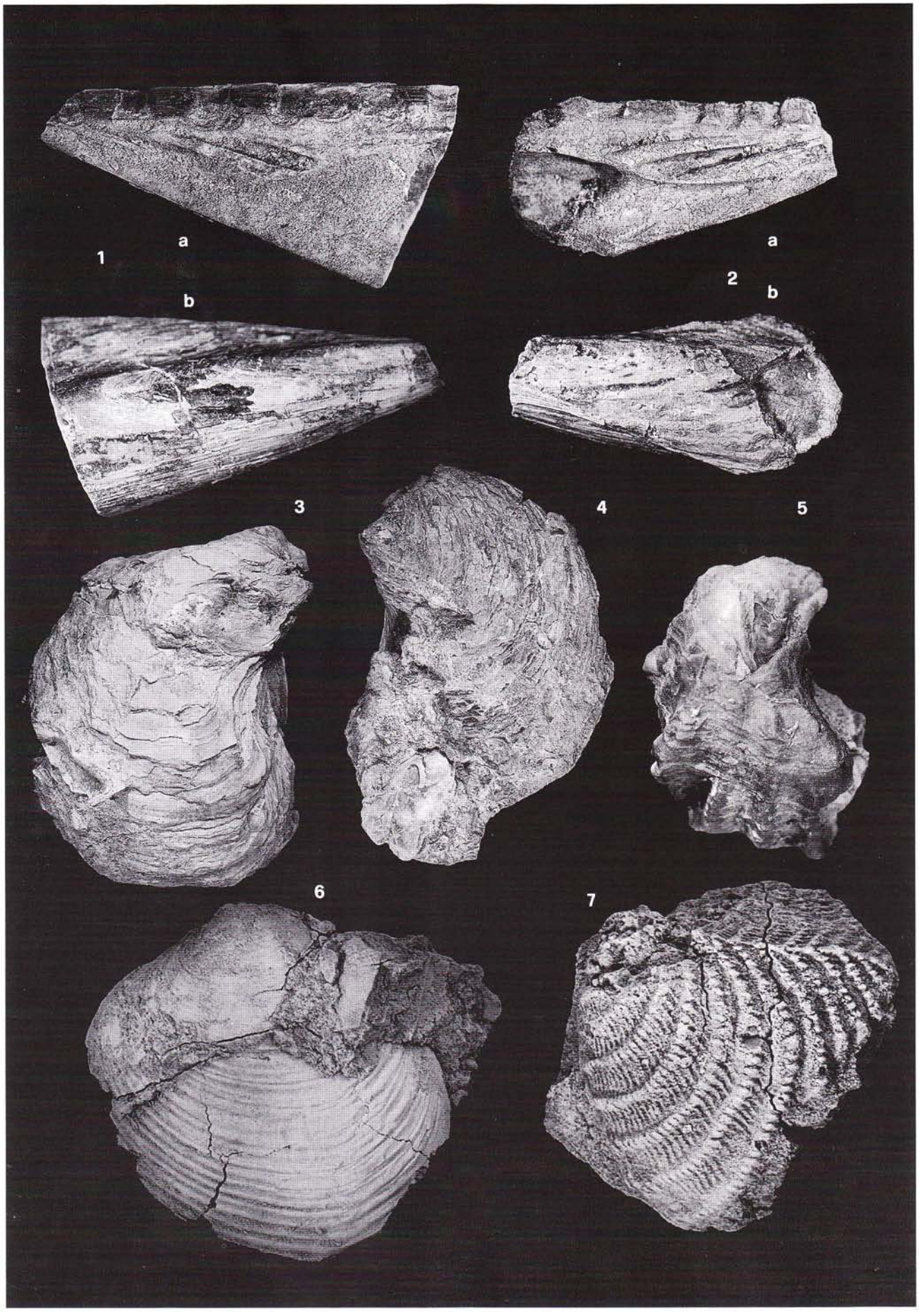
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range of the English *Epicheloniceras martinioides* Zone. At least in the area investigated the faunas indicate only the upper part of the latter Zone, i. e. the *Epicheloniceras buxtorfi* Subzone.

The bivalve faunas are typical of generally shallow, sandy facies. Though affinities with the bivalves of the Isle of Wight are undeniable, this Tethyan fauna contains also elements which are only known from the Caucasus - Mangyshlak - Turkmenistan area. On the other hand, Delanoy et al. (1997) and Cecca et al. (1999), recently reported from the La Bédoule area (SE France) numerous ammonites previously quoted from Turkmenistan only, such as *Deshayesites antiquus*, *D. tuarkyricus*, and *D. luppovi*.

Therefore, the Turkmenian biota does not seem to have been biogeographically isolated from other areas. The impoverished character of the ammonite fauna is probably due to peculiar palaeoenvironmental constraints such as water temperature and low depth.

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