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Albian ammonite biostratigraphy of the Northern Caucasus

E. J. Baraboshkin, Moscow

With 9 figures and 2 tables

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Abstract: Detailed investigation of Albian deposits in the Northern Caucasus and bed-by-bed macrofossil collecting have provided material for a new ammonite biostratigraphic scheme of the region. The proposed scheme is similar to the scheme for Georgia. It is based mainly on the zonation for the European Province. The scheme includes zones which are determined by endemic ammonites also. General information on the composition of the sections, thickness and stratigraphical significance of bivalves, belemnites and other groups of fauna are considered. Some details of zonal correlation and marine Basin connections are discussed in the paper.

Zusammenfassung: Hochauflösende Untersuchungen an sedimentären Abfolgen des Alb im nördlichen Kaukasus sowie horizontierte Makrofossilaufsammlungen bilden die Grundlage für die vorliegende biostratigraphische Ammonitengliederung dieser Region. Die hier vorgestellte Gliederung, die dem für Georgien gültigen Schema entspricht, basiert auf der Zonierung der europäischen Provinz. Das Schema beinhaltet jedoch auch Zonen, die auf endemischen Ammoniten beruhen. Allgemeine Informationen über die Zusammensetzung der Profile, die Mächtigkeit und die stratigraphische Bedeutung der Bivalven, Belemniten und anderer Makrofossilien werden berücksichtigt. Einzelheiten der biostratigraphischen Korrelation und die Bedeutung von Meeresverbindungen werden diskutiert.

Introduction

The Albian biostratigraphical scheme of the Northern Caucasus based on ammonites has been worked out by many scientists. The most important works were written by KARAKASCH (1897), RENGARTEN (1951, 1961), GLASUNOVA (1953a, b), LUPPOV (1952, 1961), MORDVILKO (1960-1962), DRUZCHIZ (1960), KUDRIAVTZEV (1960), DRUZCHIZ & MIKHAILOVA (1966)

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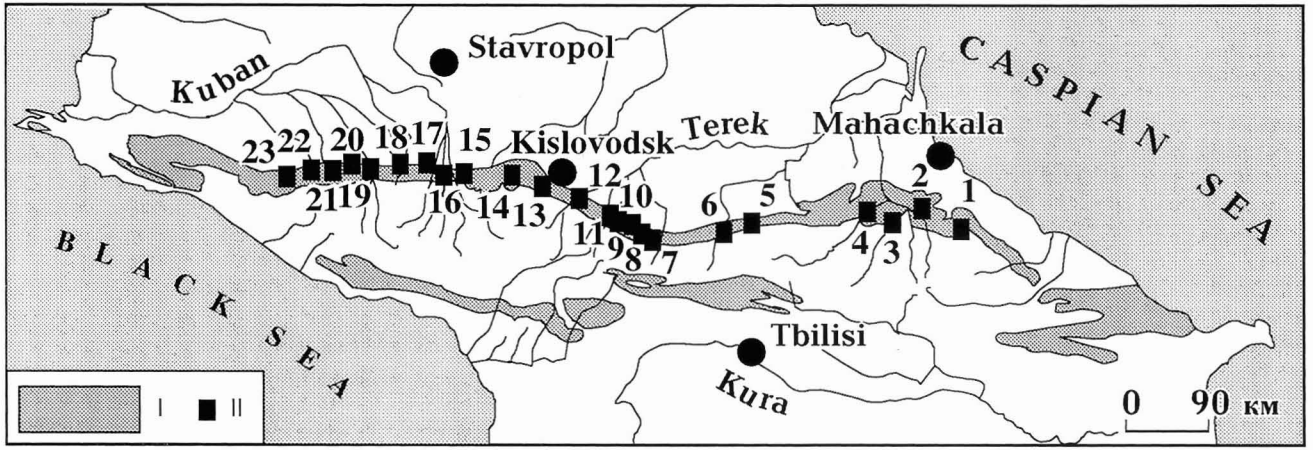

Fig. 1. Scheme of main Albian localities of the Northern Caucasus. I - Exposures of the Lower Cretaceous; II - Localities. Daghestan: **1** - Akusha Village; **2** - Gergebil Village; **3** - Avarskoe Kojsu River; **4** - Andijskoe Kojsu River; Checheno-Ingushetia; **5** - Argun River; **6** - Assa River, Northern Osetia; **7** - Gizeldon River; **8** - Fiagdon River; **9** - Ardon River; **10** - Urukh River, Kabardino-Balkaria; **11** - Heu River; **12** - Baksan River, Stavropol Region; **13** - Kislovodsk City, Karachaevo-Cherkessia; **14** - Kuma River; **15** - Kuban River; **16** - Little Zelenchuk River; **17** - Great Zelenchuk River; **18** - Urup River, Krasnodar Region; **19** - Great Laba River; **20** - Shedok River; **21** - Gubs River; **22** - Belaya River, Adygeya; **23** - Hokodz River.

Table 1. Ammonite zonal scheme of Albian of Northern Caucasus and correlation with the Anglo-Paris Basin zonal scheme.

STAGE	SUBSTAGE	H.G. OWEN, 1971–1988, LONDON – PARIS BASIN	V.P. RENGARTEN, 1951, N. CAUCASUS	I.A. MIKHAILOVA, A.A. SAVELIEV, 1989, N. CAUCASUS	E.J. BARABOSHKIN, 1996, N. CAUCASUS	E.J. BARABOSHKIN, This paper, N. CAUCASUS
		ZONE, SUBZONE	ZONE	ZONE	ZONE, SUBZONE	ZONE, SUBZONE
ALBIAN	UPPER	Stoliczkaia dispar: Mortoniceras (Durnovarites) perinflatum	ABSENT	Stoliczkaia dispar – Lepthoplites falcoides	Stoliczkaia (S.) dispar: Mortoniceras (Durnovarites) perinflatum	Stoliczkaia (S.) dispar: Mortoniceras (Durnovarites) perinflatum
		Stoliczkaia dispar: Mortoniceras (Mortoniceras) rostratum			Stoliczkaia (S.) dispar: Mortoniceras (Mortoniceras) rostratum	Stoliczkaia (S.) dispar: Mortoniceras (Mortoniceras) rostratum
		Mortoniceras inflatum: Callihoplites auritus	Pervinquieria inflata	Pervinquieria inflata	Mortoniceras (Mortoniceras) inflatum	Mortoniceras (Mortoniceras) inflatum
		Mortoniceras inflatum: Hysteroceras varicosum		Hysteroceras orbignyi	Hysteroceras varicosum	Hysteroceras varicosum
		Mortoniceras inflatum: Hysteroceras orbignyi	Hysteroceras orbignyi		Hysteroceras orbignyi	Hysteroceras orbignyi
		Mortoniceras inflatum: Dipoloceras cristatum		NOT DISTINGUISHED	Dipoloceras (Dipoloceras) cristatum	Dipoloceras (Dipoloceras) cristatum
	MIDDLE	Euhoplites lautus	ABSENT		Euhoplites lautus	Euhoplites lautus
		Euhoplites loricatus: subdelaruei + meandrinus				?
		Euhoplites loricatus: Dimorphoplites niobe				
		Euhoplites loricatus: Anahoplites intermedius	Anahoplites daghestanensis	Daghestanites daghestanensis / NOT DISTINGUISHED	Daghestanites daghestanensis / Anahoplites intermedius	Daghestanites daghestanensis / Anahoplites intermedius
		Hoplites (Hoplites) spathi	Hoplites dentatus	Hoplites dentatus	Oxytropidoceras royssianum	Oxytropidoceras royssianum
					Hoplites (Hoplites) spathi	Hoplites (Hoplites) spathi
		Lyelliceras lyelli			Lyelliceras (Lyelliceras) lyelli	Lyelliceras (Lyelliceras) lyelli
	LOWER	Otohopl. auritiformis: Pseudosonneratia (I.) steinmanni			Pseudosonneratia (Isohopl.) eodentata	Pseudosonneratia (Isohopl.) eodentata
		Otohopl. auritiformis: Otohoplites bulliensis	Douvilleiceras mammillatum	Douvilleiceras mammillatum	Douvilleiceras mammillatum: ?	Douvilleiceras mammillatum: ?
		Otohopl. auritiformis: Protohoplites (H.) puzosianus			Protohoplites (H.) puzosianus	Protohoplites (H.) puzosianus
		Otohopl. auritiformis: Otohoplites raulinianus			?	?
		Sonn. chalensis: Cleoniceras (C.) floridum			Cleoniceras (C.) floridum	Cleoniceras (C.) floridum
		Sonn. chalensis: Sonneratia kitchini				
		Sonn. chalensis: Sonneratia (G.) perinflata			?	?
		Leymeriella tardefurcata: Leymeriella regularis	Leymeriella tardefurcata and L. bogdanovitschi	Leymeriella (Neoleymeriella) bogdanovitschi	Leymeriella (Neoleymeriella) regularis	Leymeriella (Neoleymeriella) regularis
		Leymeriella tardefurcata: Hypacanthoplites milletioides		Leymeriella (Leymeriella) tardefurcata	Leymeriella (Leymeriella) tardefurcata	Leymeriella (Leymeriella) tardefurcata
		Leymeriella tardefurcata: Farnhamia farnhamensis		Proleymeriella schrammeni	Proleymeriella schrammeni	

and many others. The latest scheme has been compiled by MIKHAILOVA (MIKHAILOVA & SAVELIEV 1989), but it is not so detailed as it is for Europe and Mangyshlak. Poor exposure of clayey Albian sections usually covered by landslides together with poor preservation of fossils cause serious difficulties in investigations.

The present paper contains new data discovered by the author during field work in several Caucasus expeditions of the Moscow State University between 1986-1992. This work took place in the Karachaevo-Cherkessia region, Russia, Kabardino-Balkaria, Northern Osetia, Checheno-Ingushetia and in Daghestan (Fig. 1). The Daghestan sections were visited by the author during an expedition of the paleomagnetic laboratory of Saratov State University. The author collected carefully bed-by-bed, several hundreds of ammonites and other fossils from the sections. This work has permitted to obtain a much more accurate picture of the biostratigraphy of the Albian sections in these regions. Based on the macrofauna (mainly ammonites) determinations made by the author, a new zonation scheme has been proposed (BARABOSCHKIN 1995, BARABOSHKIN 1996c, BARABOSHKIN et al. 1997a,b). The scheme is comparable with the "standard" scheme for Mediterranean Province (HOEDEMAEKER et al. 1993) in detail, and similar to the scheme of the European Province (Table 1). On the base of this local scheme, a new magnetostratigraphic scale for the Albian of the Northern Caucasus was proposed in collaboration with paleomagnetists from the Saratov Geological Institute (BARABOSHKIN et al. 1997a,b).

Geologically, all investigated sections are situated in the northern slope of the Great Caucasus Anticlinorium or belong to the Northern Caucasus Monoclinorium (MILANOVSKY 1991). Albian sections of the region consist of black silty clays with limestone layers, pyrite concretions and phosphorites in the basal part. The dark and black colour of every Albian section of the region in many cases is the result of a high organic carbon content.

Stratigraphy

Lower Albian

Several specific features are typical for the Albian succession in the Northern Caucasus: (1) very narrow range of representatives of the families Hoplitidae, Lyelliceratidae, Mojsisovicsiidae, Mortoniceratidae and Dipoloceratidae (including zonal indexes, usually the same species is distributed in only one bed); (2) wide range of representatives of the family Desmoceratidae, belemnites, inoceramids and aucellins (several ammonite zones to substage); (3) very different ranges of heteromorph ammonites (from single bed up to substage). Such a made of ammonite distribution was caused by sea-level oscillations probably. Because of that, the author's

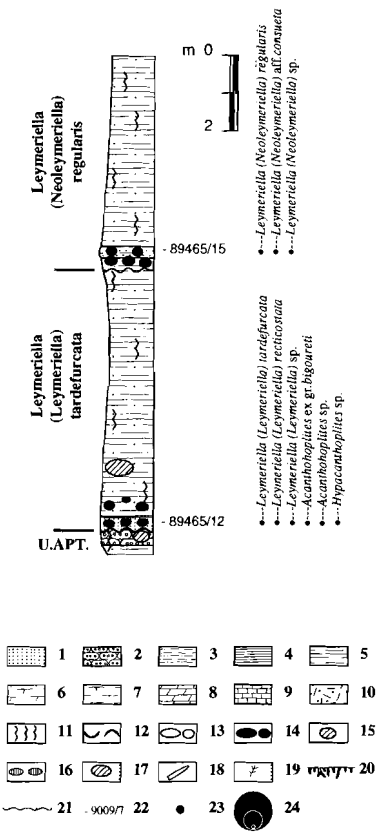

Fig. 2. Kuban River section (lower part). Position of the section see Figure 1. Legend (Fig. 2-6): **1** - sands, soft sandstones; **2** - sandstones; **3** - siltstones; **4** - clays; **5** - argillites; **6** - marly clays; **7** - carbonate clays; **8** - marls; **9** - limestones; **10** - tuff layers; **11** - bioturbation; **12** - shell detritus; **13** - pebbles of different composition; **14** - phosphatic pebbles; **15** - pyrite and marcasite concretions; **16** - barite concretions; **17** - carbonate sandstone spherical concretions; **18** - belemnite levels; **19** - plant detritus; **20** - hard/softgrounds; **21** - erosional boundaries; **22** - position of samples; **23** - fauna findings; **24** - fauna findings and its quantitative characteristics (only for Fig. 4; circles: 1, 5, 10 specimens respectively).

use of the term "zone" means the interval between the first appearance of the zonal index (including it) and the appearance of the next zonal index.

The sedimentary succession around the Aptian/Albian boundary is a difficult subject for investigation in the Northern Caucasus. In most of the sections it is badly exposed because of the landslides of Middle-Upper

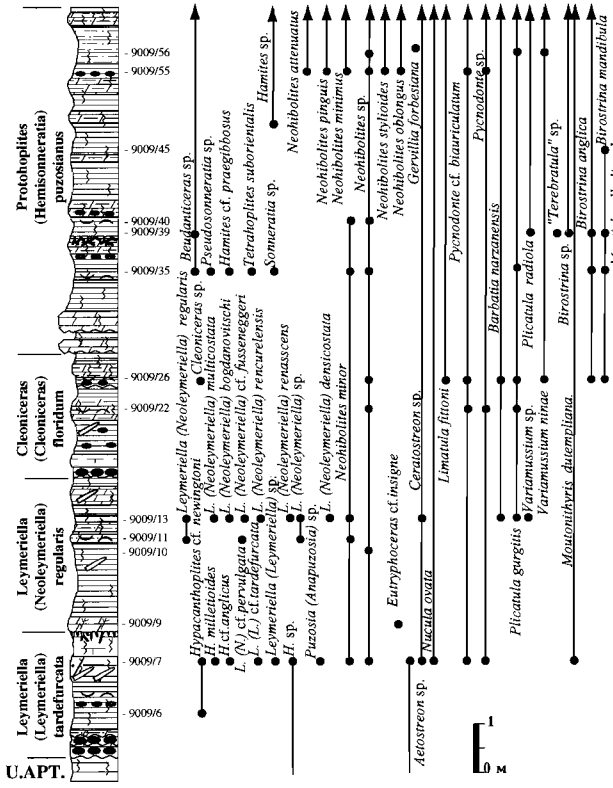

Fig. 3. Akusha Village section. Position of the section see Figure 1. The legend is on Figure 2.

Albian clays. It is strongly condensed as usual and only in a few sections does it contain well-preserved faunas. The best Aptian-Albian boundary sections visited by the author are at the Kuban River near Kubina Village (Fig. 2) and the Akusha village section on the Dargi River (Fig. 3). The Urup River DRUZCHIZ & MIKHAILOVA 1966) and Great Zelenchuk River (MORDVILKO 1960) sections are also good and contain leymeriellids.

The Albian succession starts with the *Proleymeriella schrammeni* Zone according to DRUZCHIZ & MIKHAILOVA (1966). They mentioned findings of *Proleymeriella schrammeni* and *Hypacanthoplites* ex gr. *milletioides* from grey-yellowish siltstones in the Kuma section near Krasnovostchny Village. However, careful examination of the collection of DRUZCHIZ & MIKHAILOVA and discussions on that topic with Prof. I. MIKHAILOWA have demonstrated the absence of *Proleymeriella* in the Northern Caucasus region. Thus, the previous view that the basal Subzone of the Albian was

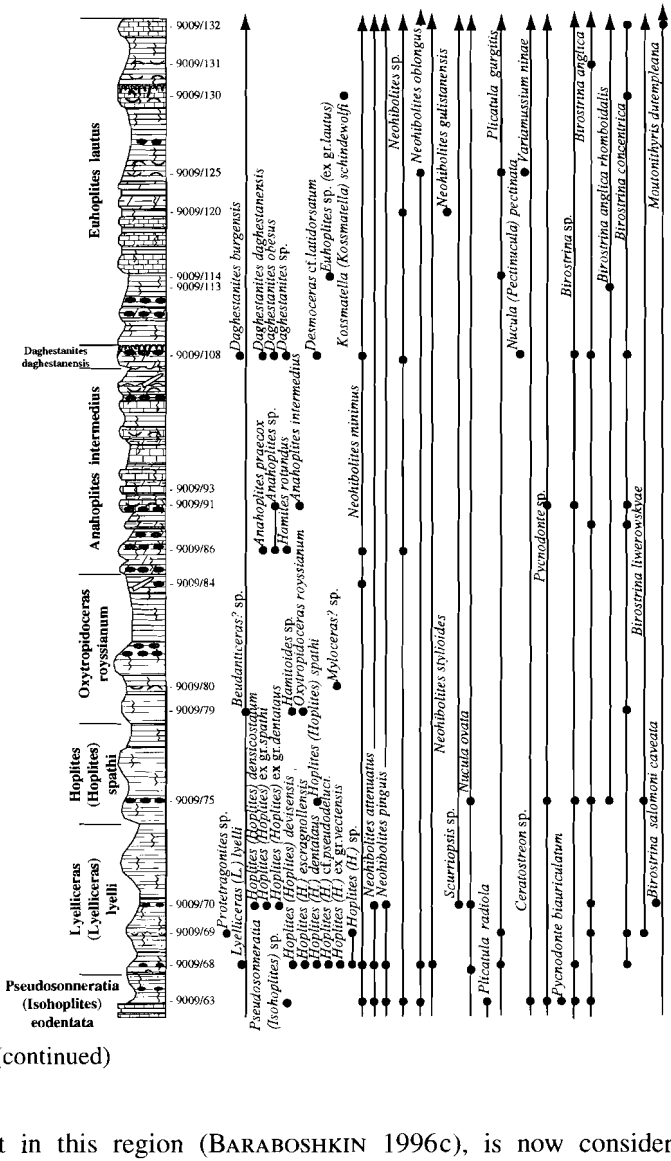

Fig. 3 (continued)

present in this region (BARABOSHKIN 1996c), is now considered to be incorrect. A short visit to one of the two candidate Aptian/Albian boundary stratotypes (Vohrum quarry near Hannover, Germany: HART et al. (1996) in 1996 showed that the *Hypacanthoplites* assemblage of the northern Caucasus associated with *Leymeriella (Leymeriella)* (see below) seems to be very poor and different from that of the *schrammeni* beds at Vohrum (see

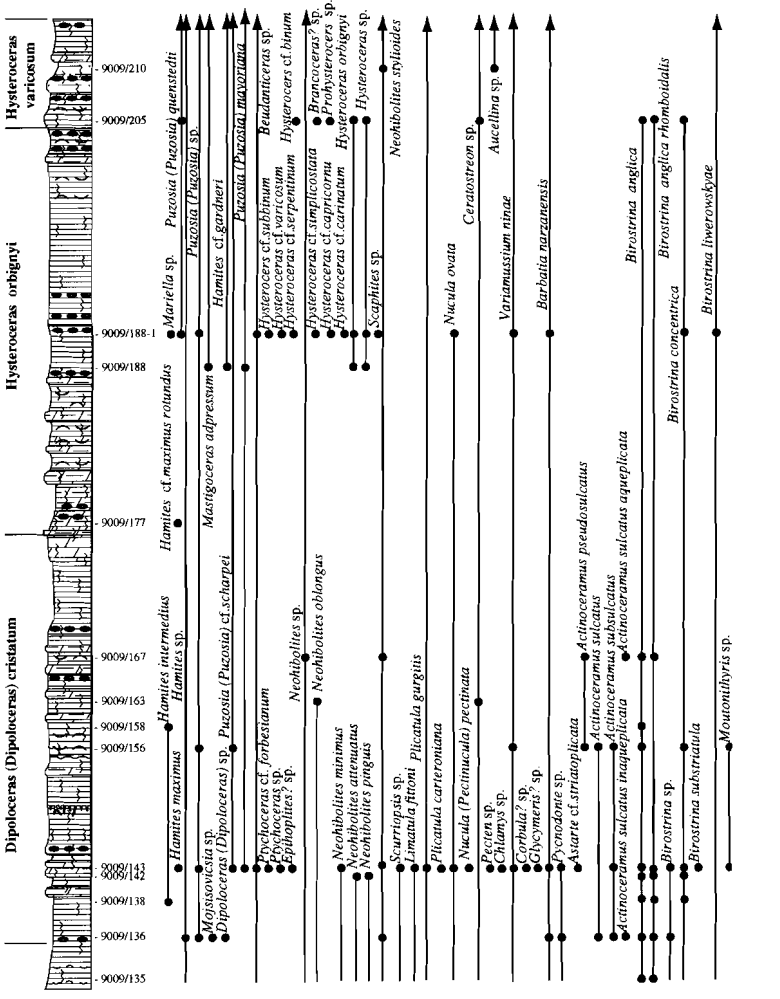

Fig. 3 (continued)

KEMPER 1975, 1982). It indicates that there is a boundary hiatus in the Northern Caucasus. On the other hand, it seems that *Proleymeriella* is quite a local genus, distributed in Germany and Spitzbergen only.

This hiatus at the Aptian/Albian boundary exist throughout the northern Caucasus sections. Apart from Kuban and Akusha, the other sections around the Aptian/Albian boundary level also present an erosional surface at the top of the Aptian succession and a phosphorite conglomerate in the base of the Albian. The hiatus falls mainly in the basal part of Albian succession.

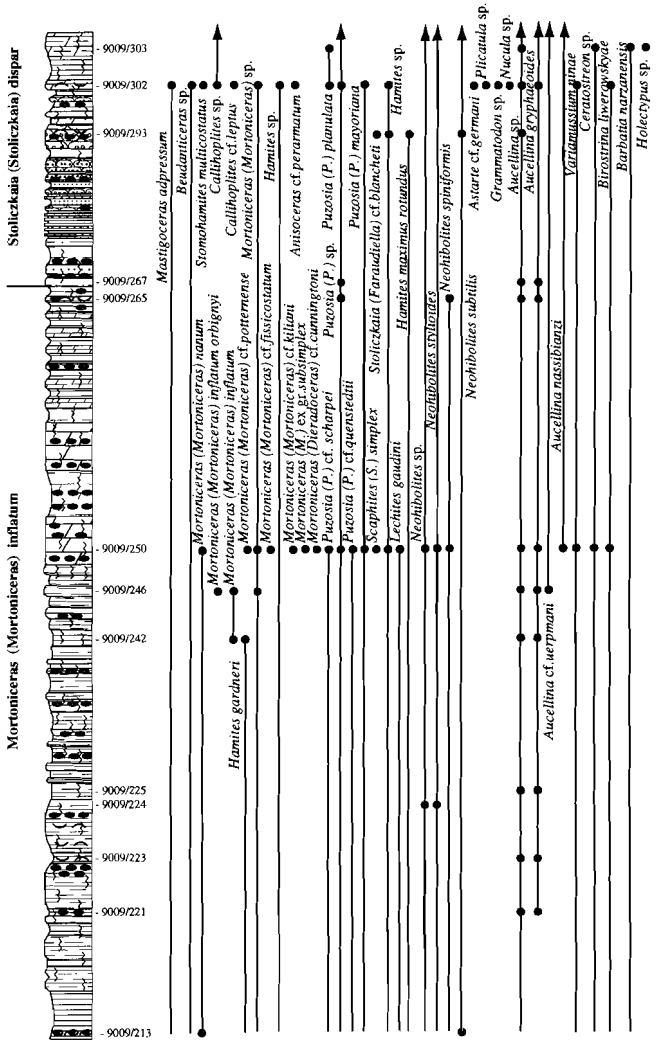

Fig. 3 (continued)

The *Leymeriella (Leymeriella) tardefurcata* Zone (the *L. (L.) acuticostata* Subzone of SPATH's standard scheme for the European Province) is represented by light green-grey siltstones and soft sandstones with phosphorite horizons at the base. The zone is characterized by *Leymeriella (L.) tardefurcata* (Fig. 7-4), *L. (L.) recticostata* (Fig. 7-3), *Hypacanthoplites milletioides* (Fig. 7-2), *H.* cf. *newingtoni, H.* cf. *anglicus* (Fig. 7-9) and

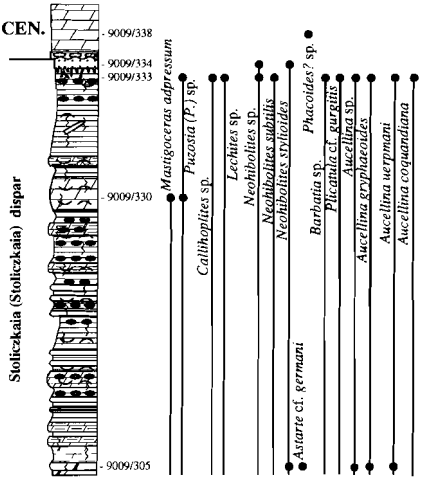

Fig. 3 (continued)

?*Puzosia (Anapuzosia)* sp. in the Kuban (Fig. 2) and Akusha sections (Fig. 3). In the Kuban section leymeriellids were found in a reworked pebble fauna. Descriptions of some ammonites from the same sections were given by SINZOW (1908) and ERISTAVI (1961). A very important fossil for this level is also the bivalve *Aucellina caucasica.* This species characterises the lower part of the *tardefurcata* Zone in the Caucasus, Mangyshlak (ERISTAVI 1940, SAVELIEV 1973) and Turkmenia (author's data). The presence of a horizon with abundant specimens of the belemnite *Neohibolites minor* is also an important feature of the zone. The *tardefurcata* Zone sediments are present in Akusha (2.6 m), Avarskoe Kojsu (?), Andijskoe Kojsu (?), Kuban (7 m), Little (?) and Great Zelenchuk (< 15 m), Urup (10-11 m) and Great Laba (?). All the data on the thickness variations here and below are taken from works of LUPPOV (1952), KUDRIAVTZEV (1960), MORDVILKO (1960-1962), RENGARTEN (1961), DRUZCHIZ & MIKHAILOVA (1966), ALIEV et al. (1985) and were revised and added to by the author. Albian deposits were eroded completely between the Khokodz and Shedok rivers (Fig. 6).

The *Leymeriella (Neoleymeriella) regularis* Zone in Daghestan is represented by black clays with rare marl layers and is delimited by an erosional surface at the top and by a softground at the base. It was recognised in Akusha (3.6 m, Fig. 3) and probably exists in the Avarskoe Kojsu and Andijskoe Kojsu Rivers sections. In the NW Caucasus it consists of grey siltstones with phosphorites at the base and is present in Kuban (7 m, Fig. 2), Litte (?) and Great Zelenchuk (?), Urup (3.5 m) and Great Laba (?). Probably it also exists in the Urukh (Fig. 4) and Heu sections. In other

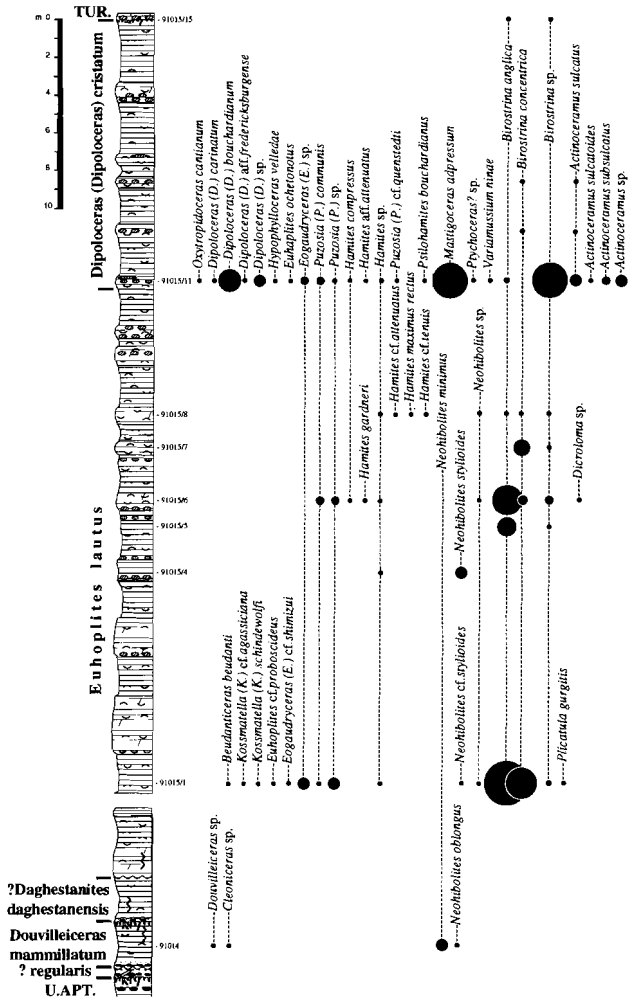

Fig. 4. Urukh River section. Position of the section see Figure 1. The legend is on Figure 2.

Table 2. (see page 186-189): Zonal distribution of ammonites in the Albian of Northern Caucasus. "+"-ammonites, found by the author or figured in the literature and examined by the author: "*"-cited in faunal lists in the literature. Letters mean zones and subzones: **t** - *tardefurcata*, **r** - *regularis*, **f** - *floridum*, **p** - *puzosianus*, **e** - *eodentata*, **l** - *lyelli*, **s** - *spathi*, **ro** - *roissyanum*, **i** - *intermedius*, **d** - *daghestanensis*, **la** - *lautus*, **c** - *cristatum*, **o** - *orbignyi*, **v** - *varicosum*, **in** - *inflatum*, **rs** - *rostratum*, **pe** - *perinflatum*.

Table 2 (legend see p. 185)

	t	r	f	p	e	l	s	ro	i	d	la	c	o	v	in	rs	pe
Phylloceratidae																	
Hypophylloceras velledae (Michelin,1834)												+	+				
Gaudriceratidae																	
Eogaudryceras (Eogaudrycaras)																	
cf.*shimizui* Breistroffer,1936											+						
sp.								+				+					
Kossmatella (Kossmatella)																	
agassiziana (Pictet,1848)											+						
schindewolfi Wiedmann,1966											+						
Lytoceratidae																	
Pictetia depressa (Pictet,1861)				*													
Tetragonitidae																	
Tetragonites timotheanus (Pictet,1847)											*						
Ptychoceratidae																	
Mastigoceras adpressum (J.Sowerby,1814)												+	+		+	+	+
Hamitidae																	
Hamites																	
attenuatus J.Sowerby,1814											+						
compressus J.Sowerby,1814											+						+
compressus gracile Spath,1941																	+
gardneri Spath,1941											+		+				
incurvatus Brown,1837															*		
intermedius d'Orbigny,1841												+					
maximus J.Sowerby,1814												+					
maximus rectus Brown,1837											+						
cf.*praegibbosus* Spath,1941				+													
rotundus J.Sowerby,1814									+				+			+	
cf.*tenuis* J.Sowerby,1814						+											
Hamitoides sp.								+									
Plesiohamites multicostatus (Brown,1837)																*	+
Psilohamites bouchardianus (d'Orbigny,1842)												+					+
Stomohamites																	
charpentieri (Pictet,1847)																*	
venetzianus (Pictet,1847)																+	
Baculitidae																	
Lechites																	
gaudini (Pictet et Campiche,1861)															+		
sp.																+	+
Sciponoceras sp.																+	+
Anisoceratidae																	
Anisoceras cf.*perarmatum* (Pictet et Campiche,1861)																+	
Turrilitidae																	
Mariella (M.) bergeri (Brongniart,1822)																+	+
cf.*miliaris* (Pictet et Campiche,1861)																+	
Ostlingoceras puzosianum (d'Orbigny,1842)																	+

Table 2 (continued, legend see p. 185)

	t	r	f	p	e	l	s	ro	i	d	la	c	o	v	in	rs	pe
Turillitoides hugardianus																	
(d'Orbigny, 1842)															*		
cf. *toucasi*																	
(Herbert et Munier-Chalmas, 1875)																*	
Scaphitidae																	
Scaphites (Scaphites) simplex																	
(Jukes-Browne, 1875)															+		
Labeceratidae																	
Myloceras? sp.								+									
Desmoceratidae																	
Beudanticeras																	
beudanti (Brongniart, 1822)											+						
dupinianum africana																	
(Pervinquiere, 1907)				+													
Desmoceras latidorsatum																	
(Michelin, 1838)										+	*	+					
Puzosia (Anapuzosia) sp.	+																
Puzosia (Mesopuzosia) sp.																	+
Puzosia (Puzosia)																	
communis Spath, 1923											+	+			+		
mayoriana (J. de C. Sowerby, 1827)											*	+	+		+	+	+
planulata (d'Orbigny, 1841)																+	+
provincialis																	
(Parona et Bonarelli, 1896)															+		
quenstedti																	
(Parona et Bonarelli, 1896)																+	+
scharpei Spath, 1923																+	+
spathi Breistroffer, 1936															+	+	
Parahoplitidae																	
Hypacanthoplites																	
cf. *anglicus* Casey, 1950	+																
milletianus (d'Orbigny, 1841)	*																
milletioides Casey, 1961	+																
cf. *newingtoni* Casey, 1965	+																
Douvilleiceratidae																	
Douvilleiceras																	
mammillatum (Schlothiem, 1813)			*	*													
monile (J. Sowerby, 1816)				+													
scabrosum Casey, 1962				+													
Leymeriellidae																	
Leymeriella (Leymeriella)																	
tardefurcata (d'Orbigny, 1841)	+																
Leymeriella (Neoleymeriella)																	
bogdanovitschi Glasuniva, 1949		*															
consueta Casey, 1957		+															
crassa Spath, 1925		*															
ex gr. *diabolus* Casey, 1957		+															
cf. *fusseneggeri* Seitz, 1930		+															
jacobi Spath, 1925		*															
multicostata Saveliev, 1973		+															
cf. *pervulgata* Saveliev, 1973		+															
pseudoregularis Seitz, 1930		+															
recticostata Saveliev, 1973		+															

Table 2 (continued, legend see p. 185)

	t	r	f	p	e	l	s	ro	i	d	la	c	o	v	in	rs	pe
rencurelensis (Jacob, 1908)		+															
regularis (d'Orbigny, 1841)		+															
renascens Seitz, 1930		+															
Epileymeriella (Revilites) cf. *revilii* (Jacob, 1908)		*															
Hoplitidae																	
Anahoplites																	
intermedius Spath, 1925									+								
ex gr. *planus* (Mantell, 1822)									*								
praecox Spath, 1923									+								
Callihoplites																	
cf. *leptus* (Seely, 1865)																+	
senilis laevigatus Spath, 1927																+	
Cleoniceras (C.) sp.																	
Daghestanites																	
burgensis Glasuniva, 1953										+							
daghestanensis Glasuniva, 1953										+							
obesus Glasuniva, 1953										+							
Epihoplites sp.												+					
Euhoplites																	
ex gr. *lautus* (J. Sowerby, 1821)											+						
ochetonotus (Seely, 1864)												+					
cf. *proboscideus* (J. Sowerby, 1821)											+						
truncatus Spath, 1925											*						
Hoplites (Hoplites)																	
benettianus (J. de C. Sowerby, 1826)																	
densicostatum Spath, 1923						+											
dentatus (J. Sowerby, 1821)						+											
devisensis Spath, 1925						+											
escragnollensis Spath, 1925						+											
escragnollensis ordinaris Glasunova, 1949						+											
latesulcatus Spath, 1925						*											
pseudodeluci Spath, 1925						+											
spathi Breistroffer, 1940						+											
cf. *vectensis* Spath, 1925																	
Lepthoplites sp.						+											*
Pseudosonneratia (Pseudosonneratia)																	
ex gr. *occidentalis pluricostata* Casey, 1965				+													
P. (Isohoplites) sp.					+												
Sonneratia (Sonneratia)																	
dutempleana (d'Orbigny, 1841)				*													
sp.				+													
Tetrahoplites				+													
suborientalis Saveliev, 1960				*													
rossicus (Sinzow, 1907)																	
Lyelliceratidae																	
Lyelliceras (Lyelliceras)																	
lyelli (d'Orbigny, 1841)						+											
Stoliczkaia (Faraudiella) cf. *blancheti* (Pictet et Campiche, 1857)																+	
Stoliczkaia (Stoliczkaia)																	

Table 2 (continued, legend see p. 185)

	t	r	f	p	e	l	s	ro	i	d	la	c	o	v	in	rs	pe
clavigera (Neumayr, 1875)																*	+
dispar (d'Orbigny, 1841)																	
Brancoceratidae																	
Brancoceras? sp.														+			
Hysteroceras																	
cf. *binum* (J. Sowerby, 1815)														+			
cf. *capricornu* Spath, 1934																	
carinatum Spath, 1922																	
orbignyi (Spath, 1922)													+	+			
serpentinum Spath, 1934													+				
ex gr. *simplicicosta* Spath, 1934													+				
cf. *subbinum* Spath, 1934													+				
varicosum (J. de C. Sowerby, 1824)													+	+			
Mojsisovicziidae													+				
Dipoloceras													+				
bouchardianum (d'Orbigny, 1841)												+					
cristatum (Brongniart, 1822)												+					
aff. *fredericksburgense* Scott, 1928												+					
Mojsisoviczia sp.												+					
Oxytropidoceras																	
cantianum Spath, 1930												+					
roissyanum (d'Orbigny, 1841)								+									
Mortoniceratidae																	
Prohysteroceras (Goodhallites) sp.													+				+
Prohysteroceras (Neoharpoceras)																	
cf. *coptense* Spath, 1934																*	
Mortoniceras (Cantabrigites)																	
subsimplex Spath, 1933															+		
Mortoniceras (Deiradoceras)																	
cf. *cunningtoni* Spath, 1933															+		
Mortoniceras (Durnovarites) sp.																	+
Mortoniceras (Mortoniceras)																	
cf. *fissicostatum* Spath, 1932															+		
cf. *kiliani* (Lassvitz, 1904)															+		
nanum Spath, 1933															+		
potternense Spath, 1932															+		
inflatum (J. Sowerby, 1818)															+		
rostratum (J. Sowerby, 1817)																+	
sp.													+		+	+	

sections it is strongly condensed and does not contain an ammonite fauna or is absent altogether. The ammonite assemblage is more varied and represented mainly by *Leymeriella (Neoleymeriella) regularis* (Fig. 7-5), *L. (N.) bogdanovitschi, L. (N.) consueta* (Fig. 7-6), *L. (N.) pervulgata, L. (N.) rencurelensis, L. (N.) multicostata* (Fig. 7-11), *L. (N.) renascens* (Fig. 7-8), *L. (N.)* cf. *fusseneggeri*, etc. (Table 2). The zone was formerly recognised as *tardefurcata-bogdanovitschi* Zone (MORDVILKO 1960-1962, DRUZCHIZ & MIKHAILOVA 1966). SAVELIEV (1973) demonstrated that the species *bogdanovitschi* belongs to the subgenus *Neoleymeriella* and appears later

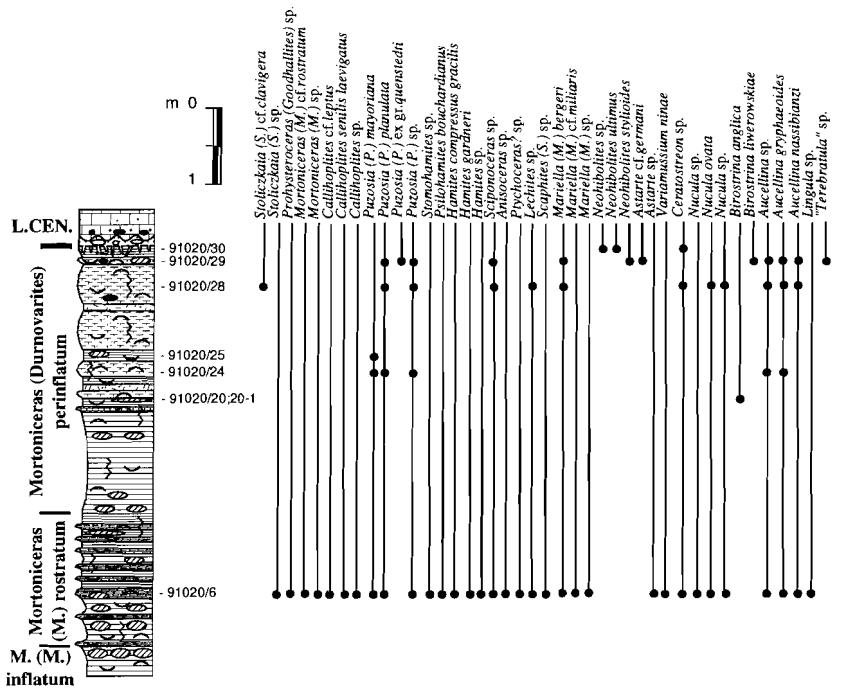

Fig. 5. Heu River section (upper part). Position of the section see Figure 1. The legend is on Figure 2.

than *Leymeriella (L.) tardefurcata.* For that reason and the widespread distribution of *L. (N.) regularis*, the author now prefers to use the *L. (N.) regularis* as index for this zone in the northern Caucasus region. The zone is also characterized by the presence of the Lower Albian belemnite *Neohibolites minor.*

The *Douvilleiceras mammillatum* Zone was previously recognised in the Great Zelenchuk (about 8 m), Shedok (45 m), Kuma, Kislovodsk (10 m) and Heu (7-10 m – author's data) sections due to the findings of *Douvilleiceras* of the *mammillatum* group (DRUZCHIZ & MIKHAILOVA 1966, MORDVILKO 1960). Careful examination of the collection of DRUZCHIZ & MIKHAILOVA has demonstrated the absence of the true *D. mammillatum*, but the presence of *Douvilleiceras scabrosum* in the NW Caucasus sections. It was considered by former stratigraphers that sediments of the *D. mammillatum* Zone are missing in the Daghestan region (GLASUNOVA 1953b, KUDRIAVTZEV 1960, MORDVILKO 1962). At the same time MORDVILKO (1962) mentioned the occurrence of *"Sonneratia* (i.e.

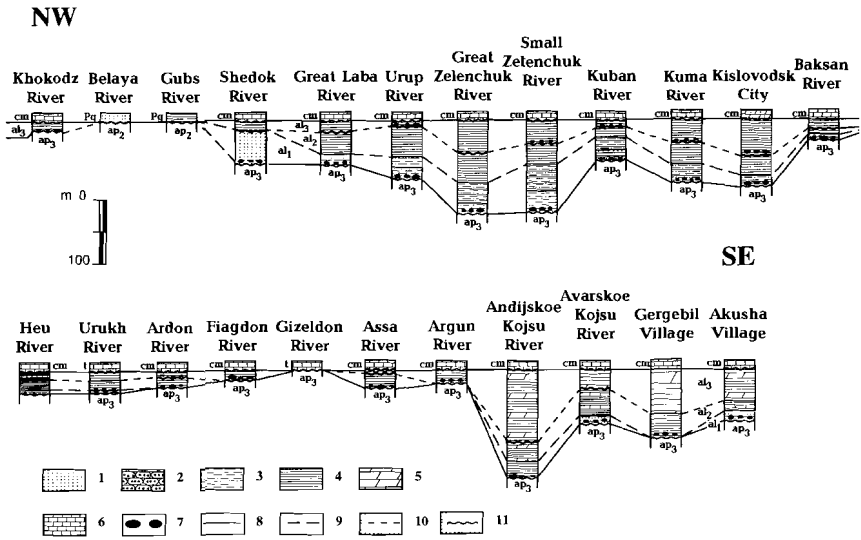

Fig. 6. Scheme of the distribution and thickness variations of Albian of the Northern Caucasus (after LUPPOV 1952, KUDRIAVTZEV 1960, RENGARTEN 1961, MORDVILKO 1960, 1962, DRUZCHIZ & MIKHAILOVA 1966, ALIEV et al. 1985, with changes and additions by the author). The position of the section seen on Figure 1. Legend: **1** - soft sandstones; **2** - sandstones; **3** - siltstones; **4** - clays; **5** - marls; **6** - limestones; **7** - phosphorites and phosphorite pebbles, correlation lines; **8** - for the Albian Stage; **9** - for Lower/Middle Albian boundary; **10** - for Upper/Middle Albian boundary; **11** - stratigraphic unconformities.

Tetrahoplites) sp. ex gr. *rossica"* from the Akusha section – a typical ammonite of the *mammillatum* Zone. Recent findings of ammonites in the Akusha section permit the recognition within the *mammillatum* Zone of the subzones of *Cleoniceras (C.) floridum* and *Protohoplites (Hemisonneratia) puzosianus* (BARABOSHKIN 1996c, BARABOSHKIN et al. 1997a): *Cleoniceras (C.) floridum* Subzone and *Protohoplites (Hemisonneratia) puzosianus* Subzone.

The sediments of the *Cleoniceras (Cleoniceras) floridum* Subzone contains a lot of small (1-3 cm) *Cleoniceras (C.)* sp. and reach a thickness of 2.55 m. The diversity of species within *Cleoniceras* is a characteristic feature of the *floridum* Subzone interval or it's analogues in many regions (CASEY 1966, OWEN 1988, DESTOMBES 1979, LUPPOV 1961, SAVELIEV 1992.) and it is a reason for the identification of that interval. The subzone is also recognised by the author in the Urukh section (Fig. 4), where large

Cleoniceras (C.) sp. were found with *Douvilleiceras* sp. indet. The thickness of the sediments of this subzone in the Urukh River is about 2 m.

The *Protohoplites (Hemisonneratia) puzosianus* Subzone is characterized by *Tetrahoplites suborientalis* (Fig. 7-10), *Sonneratia (Sonneratia)* sp. (Fig. 7-7 and *Pseudosonneratia (P.)* sp., ex gr. *occidentalis pluricostata* (Fig. 7-13). The discovery of *Tetrahoplites rossicus* by MORDVILKO (1962) was in sediments of this subzone. It is probable that *Douvilleiceras monile* was found in limestones of that subzone (Fig. 7-1) in Akusha by geologists from Northern Caucasus Geological Survey. The occurrence of *Tetrahoplites* here defines the *puzosianus* Subzone as well as it does in the Mangyshlak sections (MIKHAILOVA & SAVELIEV 1989, SAVELIEV 1992). The thickness of sediments of this subzone is 7.22 m.

Fig. 7

1. - *Douvilleiceras monile* (J. SOW.), No. 1244/5(δ), Museum of Northern Caucasus Geol. Survey, Essentuki City. Lower Albian, *Douvilleiceras mammillatum* Zone, Coll. Northern Caucasus Geol. Survey. **2**. - *Hypacanthoplites milletioides* CASEY, No. 90009/7-17. Lower Albian, *Leymeriella (L.) tardefurcata* Zone. **3**. - *Leymeriella (Leymeriella) recticostata* SAVELIEV, No. 89465/12-1-1. Lower Albian, *Leymeriella (L.) tardefurcata* Zone. **4**. - *Leymeriella (Leymeriella) tardefurcata* (LEYM.), No. 89465/121-2. Lower Albian, *Leymeriella (L.) tardefurcata* Zone. **5**. - *Leymeriella (Neoleymeriella) regularis* (BRUG.), No. 1866. Lower Albian. *Leymeriella (Neoleymeriella) regularis* (BRUG.) Zone. I. A. MIKHAILOVA. **6**. - *Leymeriella (Neoleymeriella) consueta* CASEY, No. 1866/1. Kuban River, Lower Albian. *Leymeriella (Neoleymeriella) regularis* (BRUG.) Zone. I. A. MIKHAILOVA coll. **7**. - *Sonneratia (S.)* sp. No. 90009/35-23. Lower Albian, *Douvilleiceras mammillatum Zone. Protohoplites (Hemisonneratia) puzosianus* Subzone. **8**. - *Leymeriella (Neoleymeriella) renascens* SEITZ, No. 90009/1316. Lower Albian, *Leymeriella (Neoleymeriella) regularis* Zone. **9**. - *Hypacanthoplites* cf. *anglicus* CASEY, No. 90009/7-38. Lower Albian, *Leymeriella (L.) tardefurcata* Zone. **10**. - *Tetrahoplites suborientalis* SAV., No. 90009/35-17. Lower Albian, *Douvilleiceras mammillatum* Zone, *Protohoplites (Hemisonneratia) puzosianus* Subzone. **11**. - *Leymeriella (Neoleymeriella) multicostata* SAV., No. 90009/13-19. Lower Albian, *Leymeriella (Neoleymeriella) regularis* Zone. **12**. - *Pseudosonneratia (Isohoplites)* sp., No. 90009/63-56. Middle Albian, *Pseudosonneratia (Isohoplites) eodentata* Zone. **13**. - *Pseudosonneratia (Pseudosonneratia)* sp. (ex gr. *Pseudosonneratia (P.) occidentalis pluricostata* CASEY), No. 90009/352. Lower Albian, *Douvilleiceras mammillatum* Zone, *Protohoplites (Hemisonneratia) puzosianus* Subzone. **14**. - *Hoplites (Hoplites) benettianus* (J. DE C. SOW.), No. B-92/4, Museum of Northern Caucasus Geol. Survey, Essentuki City. Middle Albian, *Leyelliceras (L.) lyelli* Zone. Coll. Northern Caucasus Geol. Survey. **15**. - *Lyelliceras (Lyelliceras) lyelli* (LEYM.), No. 90009/68-24. Middle Albian, *Lyelliceras (L.) lyelli* Zone.

The specimens if not indicated otherwise are kept in the Department of Historical and Regional Geology, MSU, Moscow, author's collection. All figures are approximately 4/5 natural size. Samples on Figs. 1-2, 7-15 are from Akusha River, Fig. 3-5 from Kuban River sections.

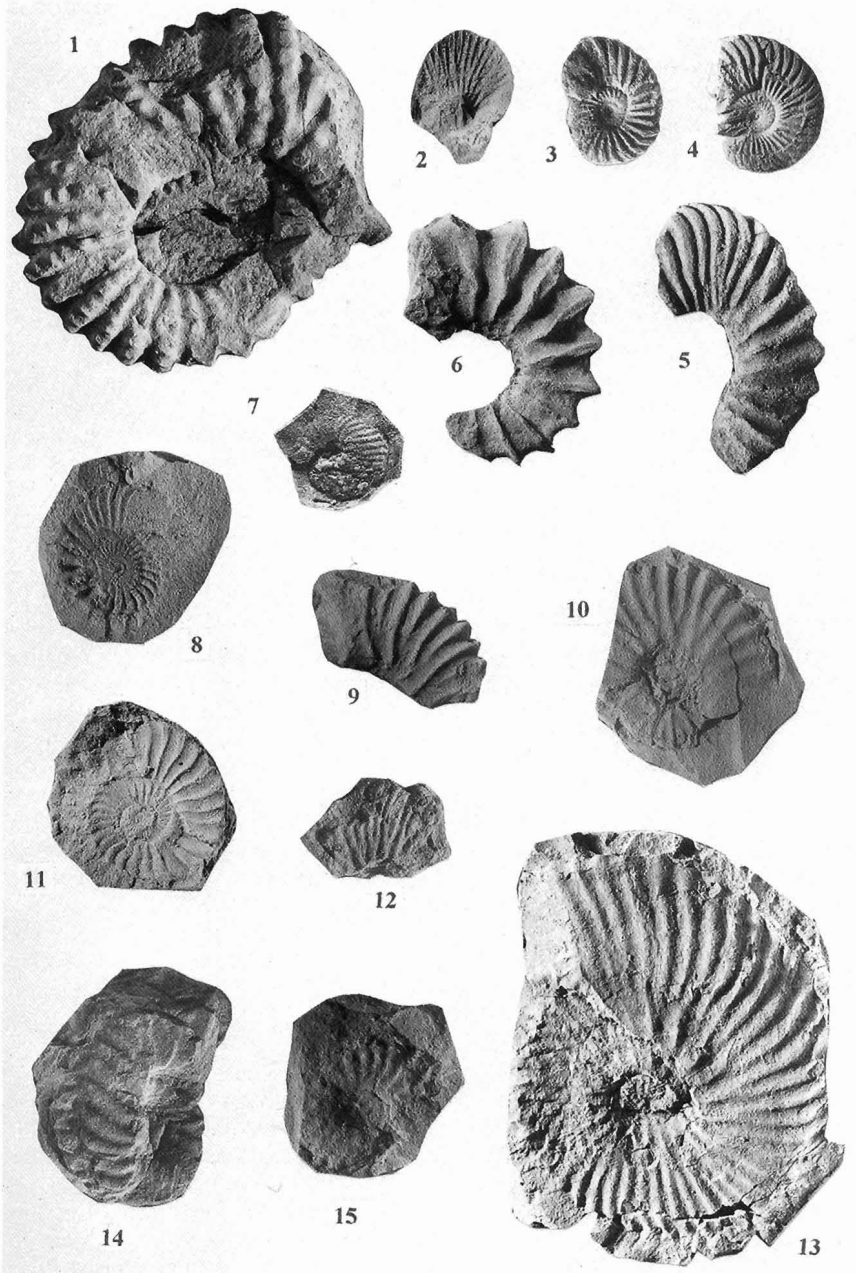

Fig. 7 (Legend see p. 192)

It was thought that the *Sonneratia (Globosonneratia) perinflata* Subzone was represented in this region by the record of *S. (G.) perinflata* (= *obesa,* DRUZCHIZ & MIKHAILOVA, 1966) in sandstones of the Shedok River section. Previously, this finding was determined by DRUZCHIZ (1960) as *Sonneratia (Globosonneratia) coronatiformis.* Unfortunately, this specimen was not found in the collection of DRUZCHIZ & MIKHAILOVA, but it was collected from sediments which included *Douvilleiceras scabrosum* the characteristic fossil of the *puzosianum* Subzone. The very first determination of this specimen of *Sonneratia,* preserved on the label, was *"Sonneratia dutempleana"*, i.e. the original determination indicates the *puzosianum* Subzone according to CASEY (1965) and OWEN (1988). Specimens of the subgenus *Globosonneratia* mark the presence of analogues of the *perinflata* Subzone (OWEN 1988) or the *globulosa* Subzone (SAVELIEV 1992) of the basal *mammillatum* Zone, in different parts of Europe. Unfortunately, the correct determination of this unique specimen as well as the stratigraphical representation of this subzone cannot be determined at present. It means that the presence of the *perinflata* Subzone in the northern Caucasus is very uncertain. For that reason the subzone is not represented in the biostratigraphical scheme (Table 1).

The *Douvilleiceras mammillatum* Zone is represented in Daghestan by black clays with marl and limestone layers in the upper part. Limestones disappear from the succession in a westerly direction simultaneously with a decrease of the thickness. Possibly this phenomenon is connected with condensation and erosion in the succession. In the NW Caucasus, the zone is

Fig. 8

1. - *Hoplites (Hoplites) spathi* BREISTR., No. 90009/75-(1-2). Middle Albian, *Hoplites (H.) spathi* Zone. **2**. - *Daghestanites daghestanensis* (GLAS.), No. 1272/1, Museum of Northern Caucasus Geol. Survey, Essentuki City. Middle Albian, *Daghestanites daghestanensis* Zone. Coll. of Northern Caucasus Geol. Survey. **3**. - *Daghestanites daghestanensis* (GLAS.), No. 90009/108-21. Middle Albian, *Daghestanites daghestanensis* Zone. **4**. - *Hoplites (Hoplites) devisensis* SPATH, No. 90009/68-A. Middle Albian, *Lyelliceras (L.) lyelli* Zone. **5**. - *Oxytropidoceras* cf. *roissyanum* (D'ORB.), No. 90009/79-10. Middle Albian, *Oxytropidoceras roissyanum* Zone. **6**. - *Euhoplites ochetonotus* (SEELY), No. 91015/11-31. Middle/Upper Albian boundary level or Upper Albian *Dipoloceras (D.) cristatum* Zone. **7**. - *Mojsisovicsia* sp., No. 90010/136-18. Upper Albian, *Dipoloceras (D.) cristatum* Zone. **8**. - *Euhoplites* cf. *proboscideus* (J. SOW.), No. 91015/1-1. Middle Albian, *Euhoplites lautus* Zone. **9**. - *Anahoplites praecox* SPATH, No. 90009/86-1. Middle Albian, *Anahoplites intermedius* Zone.

The specimens if not indicated otherwise are kept in the Department of Historical and Regional Geology, MSU, Moscow, author's collection. All figures are approximately 4/5 natural size. Samples on Figs. 1-5, 7, 9 are from Akusha River, Figs. 6, 8 - from Urukh River sections.

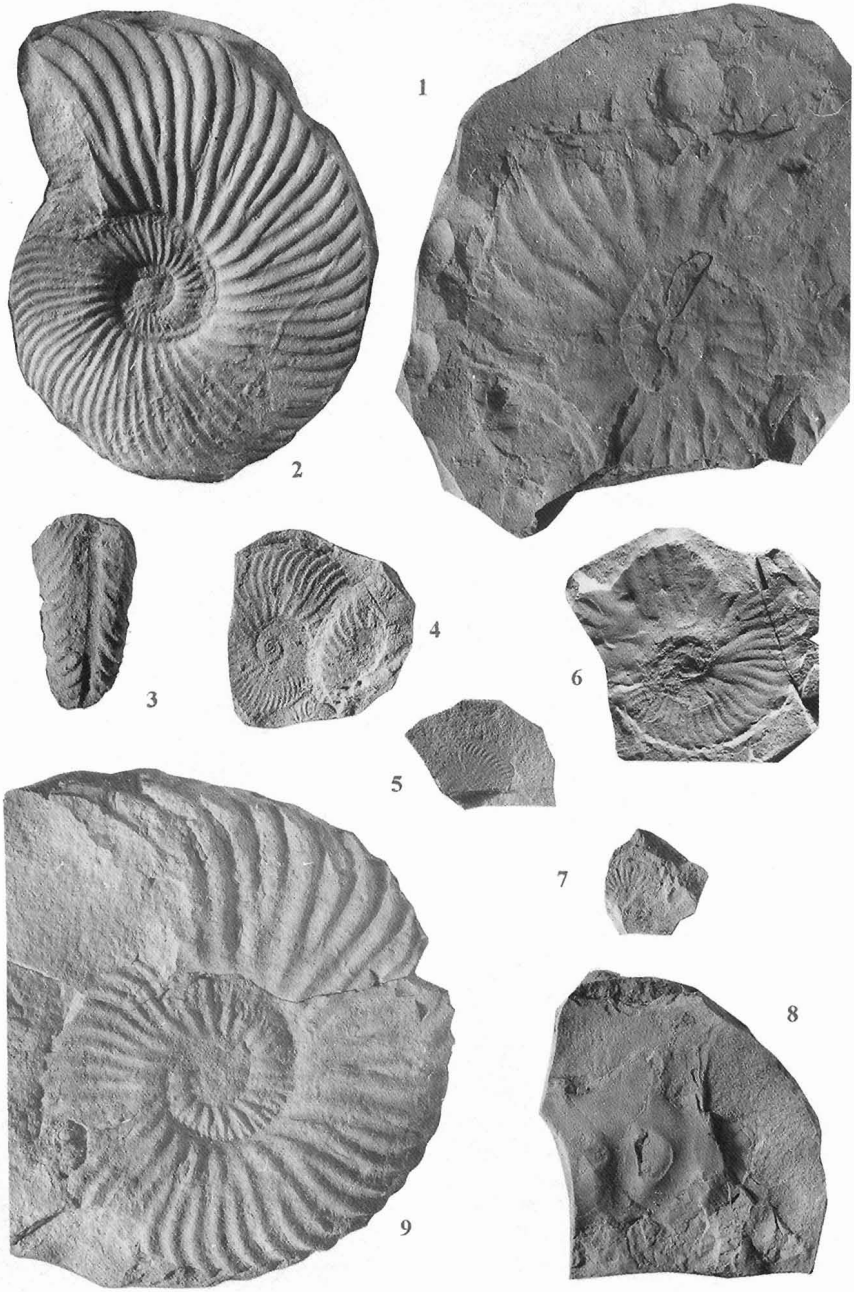

Fig. 8 (Legend see p. 194)

represented in a clayey and silty facies (Kislovodsk section) as well as in a sandy facies (Shedok, Khokodz rivers, Fig. 6).

The ammonite assemblage is accompanied by findings of inoceramids and belemnites, very important index fossils for the Albian. In the top of the *floridum* Subzone were found the first *Inoceramus anglicus* and *A. (B.) mandibula.* The latter is the characteristic fossil for the Lower Albian (SAVELIEV 1962, SAPOZHNIKOV 1972) and disappears in the *puzosianus* Subzone in the Caucasus sections according to our data.

The belemnite succession of the Lower Albian is dominated by *Neohibolites minor* in the basal part, but *N. minimus, N. stylioides, N. oblongus, N. attenuatus* and *N. pinguis* assemblage (typically Middle Albian) appear already in the *floridum* Subzone (Urukh section) and in the *puzosianus* Subzone (Daghestan).

There is as yet no evidence for the presence of any analogues of the *Sonneratia* subzones and *Otohoplites* subzones in the Northern Caucasus as in W. Europe (CASEY 1961, AMEDRO 1984, OWEN 1984a, b, 1988, HART et al. 1996), Mangyshlak (SAVELIEV 1981, 1992) and other regions, because of the rarity of ammonites in this interval. It means that the position of the lower and upper limits of the *mammillatum* Zone could change in the future.

Fig. 9

1. - *Stoliczkaia (Stoliczkaia) clavigera* (NEUM.), No. 91005/19-1. Upper Albian, *Stoliczkaia (S.) dispar* Zone. **2**. - *Mortoniceras (Mortoniceras)* cf. *potternense* SPATH, No. 90011/250-42. Upper Albian, *Mortoniceras (M.) inflatum* Zone. **3**. - *Mortoniceras (Mortoniceras) inflatum* (J. SOW.), No. 90010/24614. Upper Albian, *Mortoniceras (M.) inflatum* Zone. **4**. - *Hysteroceras* cf. *carinatum* SPATH, No. 90010/188-1-24. Upper Albian, *Hysteroceras orbignyi* Zone. **5**. - *Hysteroceras* cf. *serpentinum* SPATH, No. 90010/188-1-18. Upper Albian, *Hysteroceras orbignyi* Zone. **6**. - *Hysteroceras orbignyi* (SPATH), No. 90010/188-1-2- Upper Albian, *Hysteroceras orbignyi* Zone. **7**. - *Hysteroceras* cf. *binum* (J. SOW.), No. 90010/205-1. Upper Albian, *Hysteroceras varicosum* Zone. **8**. - *Stoliczkaia (Faraudiella)* cf. *blancheti* (PICT. et CAMP.), No. 90011/293-10. Upper Albian, *Stoliczkaia (S.) dispar* Zone. **9**. - *Mortoniceras (Mortoniceras) rostratum* (J. SOW.), No. 91020/61. Upper Albian, *Mortoniceras (M.) rostratum* Zone. **10**. - *Dipoloceras (Dipoloceras) bouchardianum* (D'ORB.), No. 91015/11-30. Upper Albian, *Dipoloceras (D.) cristatum* Zone. **11**. - *Dipoloceras (Dipoloceras) cristatum* (DELUC), No. 91015/1125. Upper Albian, *Dipoloceras (D.) cristatum* Zone. **12**. - *Oxytropidoceras roissyanum* (D'ORB.) (in the top) and *Eugaudryceras* sp., No. 90009/79-12. Middle Albian, *Oxytropidoceras roissyanum* Zone.

The specimens are kept in the Department of Historical and Regional Geology, MSU, Moscow, author's collection. All figures are approximately 4/5 natural size. Samples on Figs. 2-8, 12 are from Akusha River, Figure 1 from Baksan River, Figure 9 from Heu River, Figs. 10-11 from Urukh River sections.

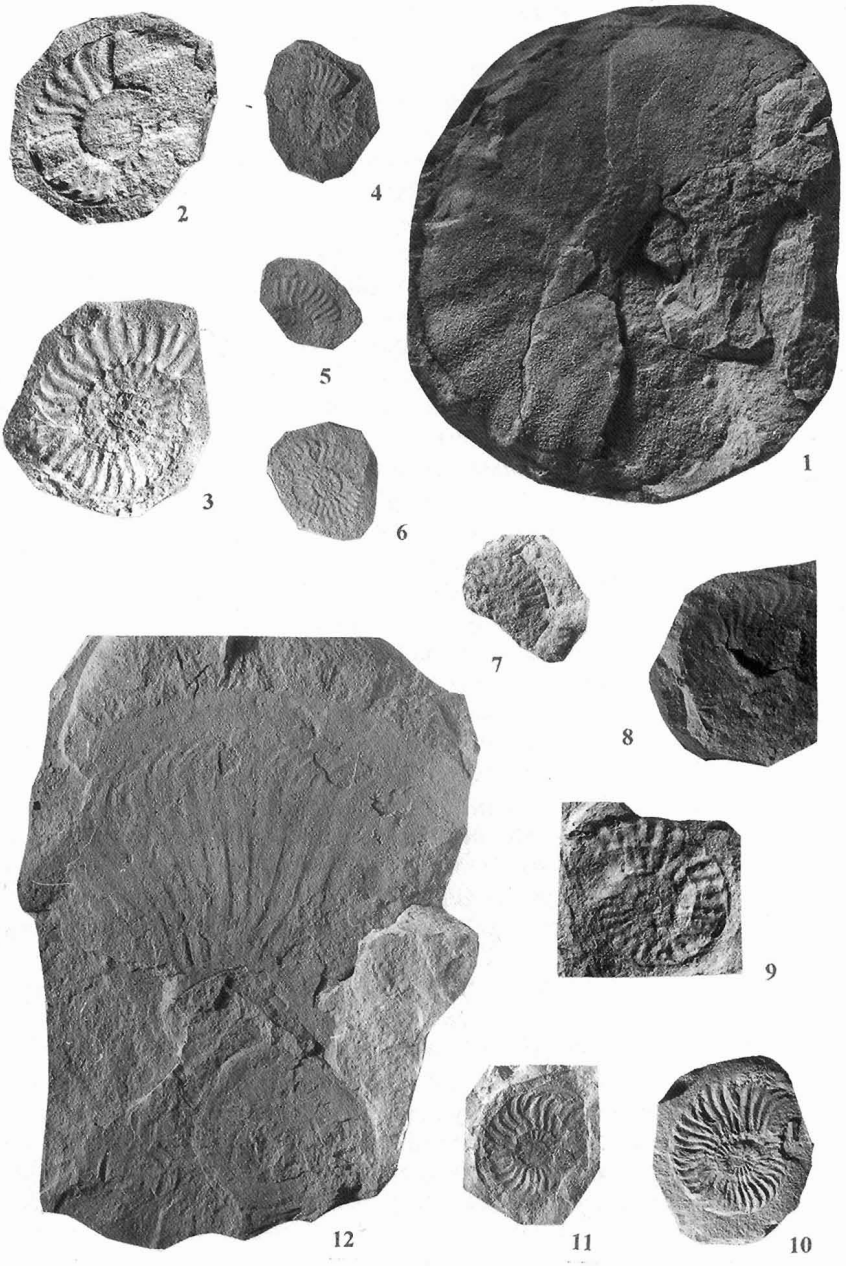

Fig. 9 (Legend see p. 196)

The upper boundary of the Zone is more "stable" based on the occurrence of *Isohoplites.*

Middle Albian

The author accepts the base of the Middle Albian as it was originally determined by CASEY (1954, 1961, 1965) and supported in early works of OWEN (1971), MIKHAILOVA & SAVELIEV (1989) and SAVELIEV (1992): by the first appearance of *Isohoplites* ammonites. These ammonites are widespread (Spitzbergen, W. Europe, Russian Platform, N. Caucasus, Mangyshlak, Turkmenia), belonging to the "Hoplitinid province" (OWEN 1973, 1988, i.e. more "boreal") and, in fact, they start the *Hoplites* succession. That is why the author cannot agree with the point of view of AMEDRO (1983) and OWEN (1984a, b) on the position of the Lower/Middle Albian boundary as well as with the change of index species.

The Middle Albian zonation is very clear in the Akusha, Urukh River and Kuban River sections. Everywhere it is represented within black clays and a clay-marl alternation with marcasite.

The succession commences with the *Pseudosonneratia (Isohoplites) eodentata* Zone defined by the presence of *Pseudosonneratia (Isohoplites)* sp. (Fig. 7.12). It was found by the author only in the Akusha section in an assemblage with *Hamites* cf. *praegibbosus* and *Beudanticeras* sp., inoceramids *(Inoceramus anglicus)* and belemnites: *Neohibolites minimus, N. oblongus, N. stylioides, N. attenuatus* and *N. pinguis.* The belemnite assemblage passes through the whole Middle Albian, up to the basal Upper Albian. Thickness of the *eodentata* Zone sediments is 2.2 m.

Following AMEDRO (1980) the present author thinks that there is no reason to unite artificially the separated *eodentata, lyelli* and *spathi* zones in a single *Hoplites (Hoplites) dentatus* Zone. They have many differences in the fauna assemblage and *Hoplites (H.) dentatus* (s. s.) was found in only one level (*lyelli* Zone).

The *Lyelliceras (Lyelliceras) lyelli* Zone is determined by the finding of the zonal index with an *Hoplites* assemblage: *Hoplites (H.) benettianus* (Fig. 7-14), *H. (H.) escragnollensis, H. (H.) dentatus, H. (H.) devisensis* (Fig. 8-4), *H. (H.)* cf. *pseudodeluci, H. (H.) vectensis*, etc. (Table 2). The zonal index was found by the author only in the Akusha section (Fig. 7-15), but the zone could be easily recognised by the wide distribution of *Hoplites* spp. Because of this association, the succession in this zone was traditionally called the *Hoplites dentatus* Zone in the Northern Caucasus. It exists in Akusha (3.1 m), in Gergebil, Andijskoe Kojsu River (about 0.5 m), Assa River, Heu, Baksan River (1 m), Kislovodsk, Kuma, Kuban, Little (about 10 m) and Great Zelenchuk River and Urup River (20 m). It the *lyelli* Zone

Actinoceramus (Birostrina) concentrica, A. (B.) liwerowskyae and *A. (B.) salomoni caveata* appear.

The sediments of the *Hoplites (Hoplites) spathi* Zone (s.s.) are made up of black clays and contain only zonal species (Fig. 8.1). It was recognised only in the section Akusha, where its thickness reaches 2.1 m. It is very possible that the *spathi* Zone is represented in most sections, where the *lyelli* Zone was found, but new faunal evidence is needed to support this idea.

The *Oxytropidoceras roissyanum* Zone overlies *spathi* Zone and consists of clays. It was recognised in the Akusha section (3.1 m) and in the Kuban River Basin (< 8 m), where *Oxytropidoceras roissyanum* and *O.* sp. were found (MORDVILKO 1960). The position of the zone and the ammonite assemblage are the same as in Georgia (KOTETISHVILI 1986): *Oxytropidoceras roissyanum* (Fig. 9.12), *O.* cf. *roissyanum* (Fig. 8.5), *Hamitoides* sp., *Myloceras*? sp. were also found there. Inoceramids *Inoceramus anglicus* and *A. (B.) concentrica* complete the faunal assemblage.

The succession is continued by the clay-limestone alternation of the *Anahoplites intermedius* Zone (4.35 m in Akusha) with *Anahoplites praecox* (Fig. 8.9), *A. intermedius, A.* sp., *Anahoplites* transitional to *Daghestanites, Hamites rotundus*, inoceramids: *Inoceramus anglicus* and *A. (B.) concentrica.* The zone is also determined in Gergebil by the presence of *Anahoplites intermedius* (ALIEV et al. 1985).

The *Daghestanites daghestanensis* Zone (0.5 m) in Akusha is represented by a single limestone layer having erosional contact at the base and a hardground at the top. It contains *Daghestanites daghestanensis* (Fig. 8.2,3), *D. burgensis, D. obesus, D.* sp. and *Desmoceras* cf. *latidorsatum.* The zone was recognised in the Avarskoe Kojsu River and other sections of Daghestan (GLASUNOVA 1953b) and was supposed by MORDVILKO (1962) to occur in Andijskoe Kojsu River section. The zone is represented also in the Kuban-Zelenchuk region, from which *Daghestanites* was shown to the author, collected by paleontologists of the N. Caucasus Geological Survey. The zone is correlated with the *niobe* Zone (MIKHAILOVA & SAVELIEV 1989) of the Anglo-Paris basin (Table 1).

No analogue of the upper part of the *loricatus* Zone (*subdelaruei* and *meandrinus* Subzones) is found yet in the N. Caucasus.

The *Euhoplites lautus* Zone terminates the Middle Albian succesion. It consists of a clay-limestone alternation in the Akusha (6.7 m) and Assa basin, and by clay-carbonate clay alternations in Fiagdon, Urukh (about 30 m, Fig. 4), Heu (> 13 m), and Baksan (10-15 m).

One of the best sections of the *lautus* Zone sediments is present in the Urukh River section, near Kalukh Village (Fig. 4). The faunal assemblage of the zone contains *Euhoplites* cf. *proboscideus* (Fig. 8.8), *Kossmatella (K.) schindewolfi, K. (K.) agassiziana, Beudanticeras beudanti,* hamitids, puzosiids, *Actinoceramus (Birostrina) concentrica* and *Inoceramus anglicus*, etc.

The *lautus* Zone in Akusha is characterized by the presence of *Euhoplites* sp. (ex gr. *lautus*), *Kossmatella (K.) schindewolfi, Actinoceramus (Birostrina) concentrica* and *Inoceramus anglicus.* In other sections, findings of *Euhoplites* ex gr. *truncatus, E.* sp., *Kossmatella (K.) agassiziana* indicate this interval (KARAKASH 1897, DRUZCHIZ & MIKHAILOVA 1966). Redeposited phosphorite moulds of *Kossmatella (K.)* cf. *agassiziana* were also found in the basal horizon of the Upper Albian in the Khokodz River (DRUZCHIZ & MIKHAILOVA 1966).

In spite of the various ranges of occurrence of *Kossmatella* in different regions (BARABOSHKIN 1996b), in the N. Caucasus, it characterises only the *lautus* Zone sediments.

Upper Albian

The Middle/Upper Albian boundary is complete and gradual, without visible disconformities, only in the Akusha (Fig. 3) and Urukh (Fig. 4) sections. The boundary "conditions" in these sections are even better than in proposed boundary stratotype in the Boulonnais (HART et al. 1996), because gaps are missing in the boundary interval of those sections and faunal record is sufficient.

The Upper Albian succession begins at the base of the *Dipoloceras (Dipoloceras) cristatum* Zone as it does all over Eurasia and N. America. The zone is recognised for the first time in the Northern Caucasus in the Akusha and Urukh outcrops. In most of the other sections it is absent because of erosion.

In Akusha it is represented by black clay-sand shelly clays with rare thin marl layers and marcasite (9 m), with *Mojsisovicsia* sp. (Fig. 8.7), *Dipoloceras (D.)* sp., *Hamites intermedius, H. maximus, Epihoplites*? sp., puzosiids, and numerous *Actinoceramus (Actinoceramus) sulcatus, A. (A.) subsulcatus, A. (A.) pseudosulcatus, Inoceramus anglicus.*

In the Urukh River section, the ammonite assemblage is more representative: *Dipoloceras (D.) cristatum* (Fig. 8.11), *D. (D.) bouchardianum* (Fig. 9.10), *D. (D.)* aff. *frederickburgense, D. (D.)* sp., *Euhoplites ochetonotus* (Fig. 8.6), *Oxytropidoceras cantianum,* large number of small *Mastigoceras adpressum, Psilohamites bouchardianus, Hamites compressus, H.* aff. *attenuatus,* puzosiids, etc. A rich assemblage of *Actinoceramus (Actinoceramus)* appears in the 5 cm below the first appearance of *Dipoloceras: A. (A.) sulcatus, A. (A.) subsulcatus, A. (A.) sulcatoides.* It differs from the Akusha section, where their appearance coincides.

A faunal characteristic of this zone is the disappearance of Middle Albian belemnites: *Neohibolites minimus, N. oblongus, N. attenuatus* and *N. pinguis* at the base of the zone and only *N. stylioides* extends through it.

The *Hysteroceras orbignyi* Zone is present within black clays with limestone beds, the latter are much more frequent in the Daghestan sections. The zone is represented in the Akusha (7.4 m), Gergebil, Avarskoe Kojsu, Andijskoe Kojsu River (4 m), Assa, Heu (3 m), and Kislovodsk sections, but elsewhere it is missing. In the Akusha section, the zone contains *Hysteroceras orbignyi* (Fig. 9.6), *H.* cf. *subbinum, H.* cf. *capricornu, H.* cf. *carinatum* (Figs. 9.4), *H.* cf. *serpentinum* (Fig. 9.5), *H.* ex gr. *simplicicosta, H.* cf. *varicosum, Mastigoceras adpressum, Scaphites* sp., *Hamites* cf. *gardneri, Actinoceramus (Birostrina) concentrica, A. (B.) liwerowskyae, Inoceramus anglicus.* Species of *Actinoceramus (Actinoceramus)* were not found in the zone in Akusha, while in the Heu and Kislovodsk region (Kich-Malka River section) they co-occurred together with the first *Mortoniceras (Mortoniceras)* sp.

The *Hysteroceras varicosum* Zone is represented by black silty clays saturated with pyrite concretions and recognised in Akusha section (2 m). ERISTAVI (1961) also figured *Hysteroceras* ex gr.*binum* (= *"Pervinquieria utaturensis"*, ERISTAVI 1961, p. 72, pl. V, fig. 7) from the Akusha section, which supports the presence of the *varicosum* Zone. It exists also in Gergebil, where *Hysteroceras varicosum* was found in a marl succession (ALIEV et al. 1985). The zone is determined by the appearance of coarse-ribbed *Hysteroceras* cf. *binum* (Fig. 9.7) and *Brancoceras*? sp. in an assemblage with *Hysteroceras* cf. *orbignyi, Inoceramus anglicus* and with the first appearance of *Aucellina* of the *gryphaeoides* group in the top of the succession.

The *Mortoniceras inflatum* Zone is represented mostly by grey marls, siltstones and sandstones (in the top) alternating with thin black clays in the Akusha section. It contains here *Mortoniceras (M.) inflatum* (Fig. 9.3), *M. (M.)* cf. *fissicostatum, M. (M.)* cf. *kiliani, M. (M.) nanum, M. (M.)* cf. *potternense* (Fig. 9.2), *M. (M.)* sp., *M. (Cantabrigites)* ex gr. *subsimplex, M. (Deiradoceras)* cf. *cunningtoni, Hamites gardneri, H.* sp., *Puzosia (Puzosia)* cf. *sharpei, P. (P.) mayoriana, Lechites gaudini* and *Scaphites (S.) simplex.* The bivalve assemblage includes *Aucellina gryphaeoides* (numerous in the top of the Zone), *A.* cf. *nassibianzi* and *Actinoceramus (Birostrina) liwerowskyae.* The zone is also characterized by the appearance of *Neohibolites subtilis* and *N. spiniformis* in addition to *N. stylioides.*

Deposits of the zone were recognized in Akusha (15.22 m), Gergebil, Avarskoe Kojsu, Andijskoe Kojsu, Argun, Assa, Fiagdon, Heu (5-7 m) and Kislovodsk (2-3 m?). Deposits of this zone were reworked westward from Kislovodsk City and remains of *"Pervinquieria"* and *"P." inflata* were found in a phosphorite conglomerate in the Little Zelenchuk-Khokodz River region (DRUZCHIZ & MIKHAILOVA 1966).

The terminal Albian is represented by the *Stoliczkaia (Stoliczkaia) dispar* Zone and two subzones: *Mortoniceras (Mortoniceras) rostratum* and

Mortoniceras (Durnovarites) perinflatum. Both subzones are distinguished in the Northern Caucasus for the first time and are described in detail in the Baksan and Heu River (Fig. 5) sections. In the other sections this interval is not as well characterized by ammonites as in the previously mentioned sections.

Deposits of the *Mortoniceras (Mortoniceras) rostratum* Subzone consist of dark-grey, finely-stratified clays with marcasite concretions at the base and alternating limestones, siltstones and clays at the top. The thickness varies from 3.5 m in Baksan to 4.1 m in the Heu section and is present also in the Akusha section. The subzone was previously recognised in Akusha by ERISTAVI (1961), who found the zonal index ammonite there. The *rostratum* Subzone is characterized by the faunal assemblage: *Stoliczkaia (Faraudiella)* cf. *blancheti* (Fig. 9-8), *Stoliczkaia (S.) clavigera* (Fig. 9-1), *Callihoplites* cf. *senilis laevigatus, Mortoniceras (M.) rostratum* (Fig. 9-9), *M. (M.)* sp., *puzosiids and Psilohamites bouchardianus, Hamites compressus gracilis, H. (H.) gardneri, H. (H.) compressus, Hamites maximus rotundus, Scaphites (Scaphites) simplex, Mariella (Mariella)* cf. *miliaris*; bivalves *Aucellina gryphaeoides, A. nassibianzi, Actinoceramus (Birostrina) liwerowskyae.* Belemnites *Neohibolites stylioides, N. spiniformis* are abundant in this zone and usually they produce "belemnite beds" in the basal parts of transgressive deposits of the *dispar* Zone (Kuma, Ardon and other sections). Possibly, the *rostratum* Zone sediments are preserved also in Kambileevka River, where *Mortoniceras (M.) rostratum* (= *"Schloenbachia inflata"*, KARAKASH 1897, pl. VI, fig. 6) was recorded.

The sediments of the *Mortoniceras (Durnovarites) perinflatum* Subzone are composed of detritic clays with phosphorites and marcasite concretions at the base; dark-grey clays with marcasite, limestones and phosphorites at the top. One of the main lithological peculiarities of the subzone is the presence of one (sections Baksan and Akusha (Fig. 3)) and two (Heu section, Fig. 5) thin (0.2-0.8 cm up to 5 cm in Akusha) tuff beds. The thickness of the subzone changes from 3.7 m in Baksan to 3.4 m in the Heu section and it is also present in Akusha. The subzone is determined by the assemblage: *Stoliczkaia*? sp., *S. (S.)* cf. *clavigera, Mortoniceras (Durnovarites?)* sp., *Anisoceras* cf. *perarmatum, Callihoplites* cf. *leptus, C.* sp., *Mastigoceras adpressum, Stomohamites multicostatus, Hamites* ex gr. *attenuatus, Mariella (Mariella) bergeri, Lechites*? sp., *Sciponoceras*? sp. and puzosiids; belemnites: *Neohibolites stylioides, N. ultimus, N. spiniformis*; bivalves: *Aucellina gryphaeoides, A. nassibianzi, Actinoceramus (Birostrina) liwerowskyae, Inoceramus anglicus.* The typical peculiarity of the uppermost part of the subzone is the presence of giant (more than 0.5 m in diameter) ammonites, *Puzosia (Mesopuzosia?)* sp.

There is no evidence of the presence in the region of the *Arrhaphoceras (Praeschloenbachia) briacensis* Subzone determined at the top of the Upper

Albian in the Mont Risou section in the Vocontian Basin, France (GALE et al. 1996) and elsewhere.

The degree of completeness and thickness of the whole dispar Zone differs widely, but everywhere it is characterized by the *Aucellina* clays. Because of that, it is easy to recognise the *dispar* Zone sediments, even if there are no ammonites present. By this way, it was determined in most of the sections: Akusha (16.5 m), Gergebil (about 30 m of marls and limestones), Avarskoe Kojsu (16-17 m), Argun (25 m), Assa (3-5), Fiagdon, Heu (7.8 m), Baksan (7.2 m), Kislovodsk (< 50 m), Kuma (7.7 m), Kuban (11 m), Small Zelenchuk (40 m), Great Zelenchuk (about 73 m), Urup (< 10 m), Great Laba (< 20 m), Shedok River (10 m) and Khokodz River (10 m).

In Urukh, Ardon, and probably Andijskoe Kojsu it was eroded during the late Cretaceous (Fig. 6).

The top of the Albian and the Albian/Cenomanian boundary succession are very different in sedimentation and completeness. There are only two sections with more or less complete boundary successions, known to the author. The section at Gergebil is probably the best one. The boundary level coincides with a marl bed (0.1 m) in a limestone/marl succession, which separates Cenomanian limestones with *Mantelliceras* and Albian *Aucellina* limestones.

There is no visible gap in the Baksan section, but a sedimentary break and the saturation of the 1-cm boundary layer with glauconite possibly could indicate a gap. This section contains ammonites and might provide evidence of the presence of the *A. (P.) briacensis* Subzone in future collecting.

The other sections always contain gaps. They appear as softgrounds with deep (0.5 m) crab burrows infilled with Cenomanian silty marls (Kislovodsk). In the Akusha section, there is an erosional gap with faunal fragments and rounded belemnites covered in glauconitite. Sometimes one can see several horizons of mature hardgrounds in the base of the Cenomanian (Kuban, Baksan, Heu, Fiagdon, Assa sections).

A general correlational scheme of the Albian sections demonstrating the principal lithology and completeness of sections is shown in Figure 6. The distribution of ammonites found and mentioned in this paper from the Northern Caucasus is shown in Table 2.

Correlation with other zonations

The proposed new ammonite zonal scheme representative in the northern Caucasus is more detailed in comparison with previous schemes, but is still far from perfect and needs further investigations, especially in the detail of the Lower Albian succession. The correlation of the Northern Caucasus scheme with the other regions has already been discussed by the author recently (BARABOSHKIN 1996a).

In general, the scheme is very similar to the scheme of KOTETISHVILI (1977, 1979, 1986) from the Georgian part of the Caucasus. It differs mainly in the absence of the subdivisions between the *Oxytropidoceras roissyanum* Zone and the "Beds with *Actinoceramus (Actinoceramus) sulcatus*" (i.e. analogues of *Dipoloceras (D.) cristatum* Zone. According to our opinion, the presence of *Kossmatella* in the interval could indicate the *Euhoplites lautus* Zone (at least) in Georgia. On the other hand, the range of *Kossmatella* in Georgia could be a little bit earlier there than in the Northern Caucasus (BARABOSHKIN 1996b). The other question is the position of the *"Aucellina gryphaeoides* Beds" that in the Northern Caucasus are referred to the *dispar* Zone, above the occurrence of *Stoliczkaia (Faraudiella)* cf. *blancheti*, i.e. younger than in Georgia.

The proposed scheme is also similar to the detailed scheme of SAVELIEV (1992) from Mangyshlak, but the latter includes many endemic ammonites even when the zones contain an "international" fauna. Some endemics of the Caspian region are good markers both for the Northern Caucasus and Mangyshlak, for example *Daghestanites*. This genus occurs at the base of the local *Hoplites perarmatus* Zone in Mangyshlak and even in the Bolshoi Balkhan (Turkmenistan, recent findings of the author). The occurrence of *Oxytropidoceras* in Mangyshlak is earlier than in the Northern Caucasus: starting from the *lyelli* Subzone (SAVELIEV 1976). It makes difficulties in respect to the *roissyanum* Zone, which should be correlated with the top of *spathi* Subzone of Mangyshlak. The Upper Albian is characterized in the Caspian region (Mangyshlak, Turkmenistan, Tadzhikistan, Iran) by the development of the ammonites genus *Semenovites* (SAVELIEV 1981, 1992, etc., GLASUNOVA 1953a, LUPPOV 1961, AMEDRO et al. 1977). It does not cause any difficulty for correlation, because almost all of the European index species are also known from this region in an assemblage with endemic taxa (SAVELIEV 1981, MIKHAILOVA & SAVELIEV 1989).

The zonation of the Russian Platform differs from the Northern Caucasus mainly in the Lower Albian, but in the Middle Albian also. The zonal scheme for the Russian Platform depends essentially on the occurrence of the hoplitids, but with periodical influence of boreal water mass (BARABOSHKIN & MIKHAILOVA 1987, 1988, BARABOSHKIN 1992, 1996a,c). Tethyan incursions possibly involving warmer water conditions from the south affected this area mainly in the Late Albian, but only a few representatives of the Lyelliceratidae and Mortoniceratidae are found there.

The biostratigraphic scheme of the Northern Caucasus is in close relation to different schemes proposed for Europe in general (SPATH 1923-1943, OWEN 1971-1996), and for France (AMEDRO 1981, 1992, DESTOMBES 1979). This is very reasonable, because all of those regions belong to the same Hoplitinid Province (OWEN 1979, 1984a,b). However, there are more similarities with the English ammonite succession, than that of the France

and especially of Southern France. The latter was influenced by warm Tethyan waters and that is why Lyelliceratidae, Brancoceratidae, Mojsisovicsiidae, Mortoniceratidae and different heteromorphs appeared a little bit earlier and were more widely distributed than in the Northern Caucasus.

There are a few difficulties which exist in the correlation of the "standard" European scheme and the Northern Caucasus scheme. For example, the *Oxytropidoceras roissyanum* assemblage belongs to the upper part of the *spathi* Zone in England and France (OWEN 1971), i.e. it is a little older than in the Northern Caucasus. The *daghestanensis* Zone of the Northern Caucasus corresponds to the *niobe* Zone as demonstrated by SAVELIEV (1976, 1980), MIKHAILOVA & SAVELIEV (1989). The analogues of the upper part of the *loricatus* Zone (*subdelaruei-meandrinus* Subzones) has not yet been found in the Northern Caucasus.

Connections with other basins

Some ideas on that topic have been published already by the author (BARABOSHKIN 1996a,c). The Northern Caucasus Basin belongs to Hoplitinid Fauna Province (OWEN 1973, 1988) and does not contain any of its own endemics. During the whole Albian the depth of the basin fluctuated from 100-150 to 200-250 m. During the lowstand of sea-level, dark clays and silts have been formed. During the highstands carbonates and carbonate clays were deposited. This system under anoxic conditions controlled the faunal distribution (BARABOSCHKIN & KOPAEVICH 1993).

In the Early Albian the Northern Caucasus Basin was connected with the Tethyan basins, but there was no straight connection between the Northern Caucasus and the Russian Platform basins. This view is supported by the presence of *Leymeriella* and *Hypacanthoplites,* prevalence of hoplitids and absence of *Arcthoplites* – a typically arctic ammonite. The development of the North Caspian region protected the Northern Caucasus Basin from the influence of cool water from the Russian Platform, but there was an exchange of fauna through the Northern Caucasus.

In the Middle Albian, sea-level rise permitted the marine connection between the Russian Platform and the Northern Caucasus. The transgression began at the end of the Early Albian and Middle Albian; *Isohoplites* spread in many basins. *Lyelliceras* penetrated to the Northern Caucasus Basin, but *Hoplites,* with its cool water tolerance, occupied the whole area. *Lyelliceras* is known from Tethyan regions and the same genus exists in Madagascar, S. Africa and S. America sections. The new impulse of transgression developed during the *roissyanum* Zone when the keeled ammonite *Oxytropidoceras* reached this area.

During the Late Albian, in the highest sea-level conditions, Tethyan warm waters covered the whole area and the same representatives of Lyellicerat-

idae, Brancoceratidae and Mojsisovicsiidae and Mortoniceratidae occupied the Northern Caucasus Basin. The same genera that exist in Africa, America, India and other regions are present in the Northern Caucasus: such as *Dipoloceras, Mojsisovicsia, Hysteroceras, Mortoniceras, Stoliczkaia,* etc. Usually, they predominate over the hoplitids in the sections. The influence of Tethyan water was even stronger than in the Caspian Basin where *Semenovites, Planihoplites, Sulcohoplites* and other endemics are present but are unknown in the Northern Caucasus.

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Address of the author:

Dr. EVGENIJ J. BARABOSHKIN, Department of Historical and Regional Geology, Geological Faculty, Moscow State University, 119899, Vorobjovy Gory, Moscow, Russia.