

*Geology*

## Zonal Dissection of Aalenian Deposits by Ammonites of the Caucasus

Mirian Topchishvili

*Academy Member, A. Janelidze Institute of Geology, Tbilisi*

**ABSTRACT.** The author, on the ground of his own materials on the characteristic complexes of ammonites from various geological sections of the Caucasus, together with all available data on the present-day biostratigraphy, has worked out a detailed scheme of zonal dissection of the Aalenian deposits of the Caucasus which is correlated with the standard zone scale of Western Europe. © 2009 Bull. Georg. Natl. Acad. Sci.

**Key words:** *the Caucasus, ammonite, argillite, sandstone, zone.*

### 1. Introduction

Aalenian deposits are widespread through the whole Caucasus and are predominantly of terrigenous composition. These deposits contain rich and diverse remnants of fossils that attracted scientists' interest for a long time. The study of the zonal stratigraphy of Aalenian deposits begins with the work by E. Migacheva [1]. In the Aalenian deposits developed in the interfluves of the Urup and Belaya Rivers (North Caucasus), she established all the zones of this stage known in Western Europe. K. Rostovtsev [2], who studied the Lower and Middle Jurassic of the Western Caucasus and Western Precaucasus, by index species established the presence of all the three standard zones of the Aalenian stage here. V. Kazakova [3] made a significant contribution to the development of the zonal stratigraphy; she studied stratigraphically allocated ammonites from the Aalenian deposits of the Northern Caucasus. Alongside with standard zones, she managed to distinguish local ones. Various problems of zonal dissection of Aalenian deposits within the South Caucasus (Azerbaijan and Georgia) have been considered in the works by T. Gasanov, V. Agaev [4] and M. Topchishvili [5].

On the ground of his own investigation of archistratigraphic ammonites and summarizing all avail-

able literature on this group of cephalopod mollusks, the author has detailed and specified some problems on the zonal stratigraphy of Aalenian deposits of the Caucasus.

When compiling the Aalenian biostratigraphic scheme, the author used the standard set of zones presented in the book [6].

Stratigraphic constructions are based on the tectonic peculiarities of the region and are in compliance with the scheme of tectonic zoning of Georgia and the Caucasus compiled by I. Gamkrelidze [7, 8]. The Aalenian deposits developed in the Northern Caucasus and in the southwestern slope lie conformably on Toarcian rocks and they are transgressively overlain by Bajocian formations. In the southeastern part of the Northern Caucasus, Aalenian deposits conformably overlie terrigenous rocks of the Toarcian age and equally conformably pass into Bajocian formations. The same picture can be observed on the Southern Slope of the Greater Caucasus. However, somewhat to the south, on the Dzirula massif of ancient basement, volcanogenic-sedimentary Bajocian rocks unconformably and with traces of washout overlie the red limestones of Lower Aalenian. Within the Georgian part of the Loki-Karabakh tectonic zone, Aalenian deposits gradually pass into volcanogenic rocks of Bajocian age, while in the Azerbaijanian part, the latter having at the

base a 2-meter-thick bed of basal conglomerates rest on the uneven surface of clayey-sandy shales of Lower Aalenian. Within the Narkhichevan area, the basal horizon of organogenic-clastic limestones of the Aalenian age transgressively covers the underlying Lower Jurassic rocks and, in turn, is transgressively overlain by sandstones, with limestone intercalations, of the Bajocian age.

## 2. Aalenian zones and ammonite associations

The southernmost outcrops of the Aalenian deposits are confined to the Araks intermontane trough, which are known only in the Aznaburt village and Negrām (Nakhichevan) station under the name – the Evinian suite. They are represented by various sandstones, clays, aleurolites and interlayers of orogenic limestones with bivalve and cephalopod mollusk fauna. The thickness of the suite does not exceed 44 m. The ammonites – *Ludwigia* sp. (cf. *umbilicata* Buck.) and *L. sp.*[9] - found in this suite, enable to attribute the most part of the Evinian suite to Late Aalenian, though a definite part of

it may be Late Bajocian. According to these ammonites, there may be distinguished a subsidiary stratigraphic unit – layers with *Ludwigia* sp., corresponding to the Upper Aalenian substage (the Murchisonae zone).

Further to the North the Aalenian deposits are developed on the territory of the Azerbaijanian part of the Loki-Karabakh zone (Fig.1). They are characterized by restricted development and occur in the headwaters of the river Asrikchai and in the Akhinchai river basin. These deposits, representing the Aalenian lower substage, make up the upper part (120m) of the Sapharlin suite, built of argillites and aleurolites, and the uppermost part – by tuffaceous sandstones. In this part of the suite remarkable are the findings of [10] *Leioceras opalinum* Rein., *Bredya subinsignis* Opp. and *Catullocceras aratum* Buck. The first two ammonites confine the stratigraphic range of enclosing deposits to the Lower Aalenian, Opalinum zone.

Within the Georgian part of the Loki-Karabakh tectonic zone the Aalenian stage with its characteristic ammonites is distinguished on the Loki salient of the

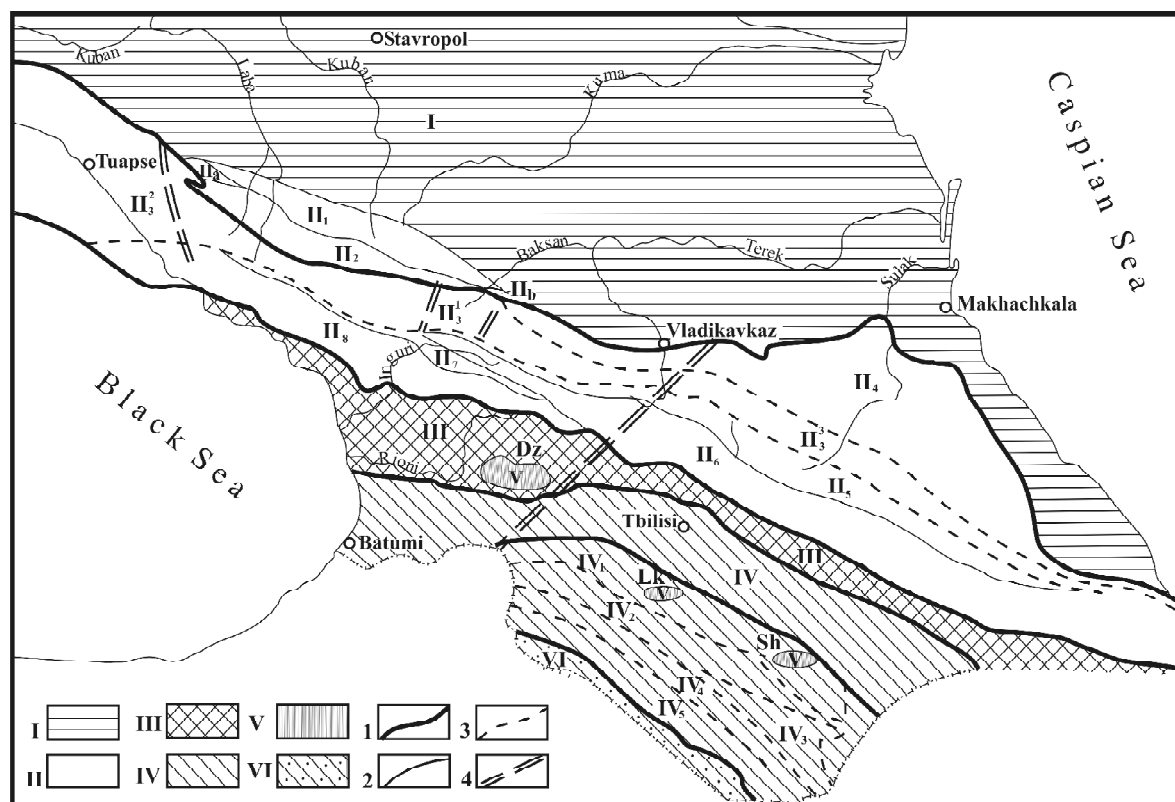


Fig. 1. Schematic map of tectonic zoning of the Caucasus

I – Pre-Caucasian (Scythian) platform; II – Fold system of the Greater Caucasus: II<sub>1</sub> – Laba-Malka zone, II<sub>a</sub>, II<sub>b</sub> – Pshkish-Tirniauz suture zone, II<sub>2</sub> – Forerange zone, II<sub>3</sub> – Main Range zone: II<sub>3</sub><sup>1</sup> – Central Uplift subzone (of the crystalline core), II<sub>3</sub><sup>2</sup> – western subsidence zone of the Main Range, II<sub>3</sub><sup>3</sup> – Eastern subsidence zone of the Main Range, II<sub>4</sub> – External zone of Mountainous Daghestan, II<sub>5</sub> – Kazbegi-Lagodekhi zone, II<sub>6</sub> – Mestia-Tianeti zone; II<sub>7</sub> – Chkhalta-Laila zone, II<sub>8</sub> – Gagra-Java zone; III – Transcaucasian intermontane area; IV – Fold system of the Lesser Caucasus: IV<sub>1</sub> – Loki-Karabakh zone, IV<sub>2</sub> – Sevan-Akera zone, IV<sub>3</sub> – Kafan zone, IV<sub>4</sub> – Miskhan-Zangezur zone, IV<sub>5</sub> – Yerevan-Ordubad zone; V – Inliers of crystalline basement (Dz – Dzirula, Lk – Loki salients and Sh – Shamkhor anticlinorium); VI – Araks intermontane trough; 1 - Boundary between tectonic units of the first order; 2 – boundary between tectonic zones; 3 – deep faults; 4 – transcurrent fault.

ancient crystalline basement, in the flyschoid rock mass of the Jandara suite – total thickness 250m. In the upper part (130-150m) of the suite both Aalenian substages with the zones Opalinum and Murchisonae are established. The assumption is justified by the Early Aalenian *Costileioceras* cf. *costosum* Quenst. and the Late Aalenian *Ludwigia murchisonae* Sow., found in argillites interstratified with aleurolites and inequigranular sandstones in the Gorastskali river gorge. The Aalenian age of the upper part of the Jandara suite is also proved by *Bredya subinsignis* Opp. and *Ludwigia* sp. (ex. gr. *murchisonae* Sow.) respectively found in the headwaters of the river Bejanazarsu [11] and in the Damblutka river gorge [12].

On the territory of the Central Uplift Zone (Transcaucasian intermontane area) the Aalenian deposits outcrop on the periphery of the Dzirula salient of the ancient crystalline basement. Within the southern, south-western and northern peripheries of the salient they are represented only by the lower Aalenian substage, separated in the upper horizons (12-13m) especially characteristic of the Mediterranean red organic limestones (“ammonitico rosso”) constituting the Shrosha suite. On the left bank of the river Kvirila, near the village of Saghvine they contain *Leioceras opalinum* Rein. and *L. comptum* Rein. and on the opposite bank at the Martotubani village – *Planammatoceras tenuinsigne* Vač. On the northern periphery of the Dzirula salient red limestones (6 m), characterized by remains of fossil fauna, are exposed in the Katskhura river gorge (environs of the village Katskhi). Here they comprise numerous representatives of mollusk fauna, among them *Costileioceras* cf. *costosum* Quenst. and *Planammatoceras tenuinsigne* Vač., together with the above-mentioned representatives of *Leioceras*, authentically prove that the upper part of the red limestones belongs to the Lower-Aalenian zone Opalinum. In these deposits the Upper-Aalenian is not preserved under the transgressive volcanogenic-sedimentary formations of the Bajocian porphyritic series.

The Aalenian deposits are significantly widespread northward –in the Gagra-Java tectonic zone. In the Abkhazian part of this zone the Aalenian builds up the upper part of the Sori suite, represented by argillites with intercalations of multilayered sandstones. In the Kodori river basin its thickness apparently does not exceed 500-600 m. Along the river Zima the argillites comprise zonal species *Leioceras comptum* Rein.

In Svaneti, the Aalenian is built of analogous deposits containing *Leioceras* cf. *opalinum* Rein. and *L. comptum* Rein. The Sori suite deposits crop out within

Racha, where the Toarcian deposits are followed by a rock mass (1000 m) with nearly the same content of sandstones and clay rocks, though in places the first element predominates over the other one. According to A.I. Janelidze [13] the above mentioned deposits comprise *Costileioceras costosum* Quenst. All these ammonites make it possible to establish the existence of the Lower Aalenian Opalinum zone in the Sori suite deposits. As for the upper substage, its existence is conventional here. In the ascending section nearly everywhere between the Aalenian terrigenous sediments and the volcanics of the Bajocian porphyritic series a gradual transition is observed. Therefore in the continuous section from the Lower Aalenian to Bajocian the existence of the Upper Aalenian should not be doubtful. The last outcrop of the Aalenian part of the Sori suite is observed in Kartli in the interfluvium of the rivers Lekhura and Aragvi; here, like the above mentioned regions of the Gagra-Java tectonic zone, the Aalenian is substantiated by specific ammonites (*Leioceras opalinum* Rein., *L. comptum* Rein. è *Costileioceras costosum* Quenst.), and is represented by its lower substage corresponding to the Opalinum zone.

On the southern slope of the Main Range of the Greater Caucasus, within the Kazbegi-Lagodekhi tectonic zone Aalenian deposits, distinguished by relatively rich fauna complex, comprising index species of ammonites as well, are developed on the territory of Kakheti. In this region the Aalenian, represented by clay shales, argillaceous-like shales with subordinate layers of sandstones and numerous argillaceous siderite concretions, is considered to constitute the Almati suite (1200 m). On the right slope of the Intsoba river gorge (environs of the village of Almati) in the suite deposits (54 m) *Leioceras opalinum* Rein., *Costileioceras costosum* Quenst., and higher up- *Ludwigia* sp. ind. [5] are observed. Among these ammonites *Leioceras* and *Costileioceras* deserve special attention; they are peculiar to the Lower Aalenian Opalinum zone. This substage is characterized by *Bredya subinsignis* Opp. from the environs of the Gremi village. Apparently, the Almati suite deposits comprise the Upper Aalenian too, as there occur species not defined to *Ludwigia*. This assumption is validated by the Late Aalenian *Costileioceras costatum* Horn., *Brasilia bradfordensis* Buck., *Ludwigia* sp., and also *Brasilia sublineata* Buck. and *Ludwigia obtusifformis buckmani* Géc. (Table 1) found in the Bolia river gorge in clay shales with sandstone interlayers and argillaceous siderite concretions (80 m) developed on the divide of the rivers Chakhuriskhevi and Saboriostskali.

All these ammonites prove the existence of the Upper Aalenian Murchisonae zone here.

In the Ilto river gorge sandstone-aleuritic clay shales with argillite-like varieties and sandstones (250 m) comprise *Costileioceras costosum* Quenst., *Leioceras* cf. *opalinum* Rein., *L.* cf. *götzendorfensis* Dorn. and *Ludwigia* sp., proving that both the Lower Aalenian (the Opalinum zone) and the Upper Aalenian are developed in these deposits.

Consequently, based on the characteristic species of ammonites, in the deposits of the Almati suite of Kakheti region of the Kazbegi-Lagodekhi tectonic zone the Aalenian stage with the zones Opalinum and Murchisonae is distinguished.

Northward, on the territory of Tusheti the Aalenian deposits are built up by clay and sandstone-aleurite-like shales with subordinate interlayers of fine-grained micaceous sandstones and heteromorphic argillaceous siderite concretions, belonging to the upper part (400-500 m) of the Kvavistskali suite (5). On the basis of *Costileioceras costosum* Quenst., *C. subcostosum* Buck., *Leioceras* sp. and *Ludwigia* sp., found in the suite, it can be ascertained that the mentioned suite comprises deposits of the Lower Aalenian Opalinum zone and layers with *Ludwigia* sp. belonging to the Upper Aalenian.

The Aalenian, especially its lower substage, comprising index ammonites is considered to be widely developed in the Kazbegi-Lagodekhi zone, which is proved by *Leioceras opalinum* Rein., *Costileioceras costosum* Quenst. and *C. subcostosum* Buck., found in

the lower horizons of clay-sandstone measures in Khevsureti (the Khakhmati and Gudani suites), Racha and Svaneti (the Gudushauri suite). The upper part of these suites is devoid of any Late Aalenian ammonites.

This blank is filled in the eastern part of the tectonic zone in the territory of Azerbaijan, where archistatigraphic species substantiates both the Lower and Upper Aalenian. The characteristic section of Aalenian deposits is situated on the river Megikanchai. Here, these deposits of the suite with the same name consist of clay shales, sandstones and aleurolites. Its lower part (230 m) comprises the relict Toarcian form *Dumortieria pseudoradiosa* Bran. and the Early Aalenian *Leioceras opalinum* Rein., *Bredya subinsignis* Opp. and *Hammatoceras rhodanicum* Renz. Along the highway Zakatala-Belokan, near the village of Tsolban *Staufenia (Costileioceras) sinon* Bayle and *Ludwigia aperta* Buck. are confined to the sandstones of the Megikan suite.

In clay-aleurolite measures (210 m) with argillaceous siderite concretions the Late Aalenian *Leioceras substriatum* Buck. and *Ludwigia murchisonae* Sow. are observed [14] along the river Katekhchai.

The Meghikan suite deposits comprising the Late Aalenian ammonites developed in the Zakatala region, southeastward of the village Matsekh. Here, in a thin limestone layer attributed to the upper horizons of the suite *Leioceras acutum* Quenst., *L. unicum* Buck., *Costileioceras cariniferum* Buck., *Ludwigia umbilicata* Buck., *L. obtusifformis* Buck. are found [14].

Table 1

Zonal complexes of Aalenian ammonites of the Caucasus

Stage	Substage	Zone	Typical complexes of ammonites of Georgia	Typical complexes of ammonites of Azerbaijan	Typical complexes of ammonites of Russian Federation
A A L E N I A N	U P P E R	CONCAVUM		<i>Graphoceras concavum</i> Sow., <i>G. rudis</i> Buck., <i>Ludwigia subtillicostata</i> Krimh., <i>L. Casta</i> Buck.	<i>Graphoceras concavum</i> Sow., <i>G. Cornu</i> Buck., <i>G. decorum</i> Buck., <i>G. rudis</i> Byck., <i>Ludwigia casta</i> Buck., <i>L. aspera</i> Buck., <i>L. Subtillicosta</i> Krimh., <i>L. micra</i> Buck., <i>L. rugosa</i> Buck.
		MURCHISONAE	<i>Ludwigia murchisonae</i> Sow., <i>L. obtusifformis buckmani</i> Géc., <i>Brasilia sublineata</i> Buck., <i>B. bradfordensis</i> Buck., <i>Costileioceras costatum</i> Horn	<i>Ludwigia murchisonae</i> Sow., <i>L. umbilicata</i> Buck., <i>L. obtusifformis</i> Buck., <i>L. aperta</i> Buck., <i>Leioceras unicum</i> Buck., <i>L. acutum</i> Quenst., <i>Staufenia (Costileioceras) sinon</i> Byle	<i>Ludwigia murchisonae</i> Sow., <i>L. cf. patula</i> Buck., <i>L. umbilicata</i> Buck., <i>L. attracta</i> Buck., <i>L. obtusifformis</i> Buck., <i>L. torta</i> Buck., <i>L. tolutaria</i> Dum., <i>L. Baylii</i> Buck., <i>L. gracile</i> Buck., <i>Brasilia bradfordensis</i> Buck., <i>B. tutcheri</i> Buck., <i>Staufenia (Costileioceras) sinon</i> Bayle, <i>St. (C.) staufensis</i> Opp. <i>Leioceras acutum</i> Quenst., <i>L. Uncum</i> Buck. et al.
	L O W E R	OPALINUM	<i>Leioceras opalinum</i> Rein., <i>L. comptum</i> Rein., <i>L. götzendorfensis</i> Dorn, <i>Costileioceras costosum</i> Quenst., <i>C. subcostosum</i> Buck., <i>Bredya subinsignis</i> Opp.	<i>Leioceras opalinum</i> Rein., <i>L. comptum</i> Rein., <i>L. götzendorfensis</i> Dorn, <i>Costileioceras costosum</i> Quenst., <i>Bredya subinsignis</i> Opp.	<i>Leioceras opalinum</i> Rein., <i>L. comptum</i> Rein., <i>L. bifidatum</i> Buck., <i>L. Götzendorfensis</i> Dorn, <i>Costileioceras costosum</i> Quenst., <i>C. subcostosum</i> Buck., <i>Bredya cf. Subinsignis</i> Opp.

Finds of the Early Aalenian ammonites *Leioceras götzendorfensis* Dorn. and *Costileioceras costosum* Quenst. are known from sandy-shaly deposits of the villages of Jukhari and Tikanly.

The Aalenian deposits spread within the eastern part of the Tfani anticlinorium as well; they compose the Karkhun suite and are represented by argillites with intercalations of aleurolites, sandstones and numerous argillaceous siderite concretions. The lower part of the suite (500 m) belongs to the Lower Aalenian. The discovered species *Leioceras opalinum* Rein., *L. comptum* Rein. and *Planammatoceras planinsigne* Vaček. prove this supposition.

The Upper Aalenian deposits (600 m) do not differ much from the lower ones. They comprise *Ludwigia subtilicostata* Krimh., *Brasilia bradfordensis* Buck. and *Graphoceras concavum* Sow., *G. rudis* Buck., discovered in the Tairdjachai, Babachai and Jimchai river basins [15].

Most of the species from the above mentioned ammonite complexes prove the existence of all the West European standard zones in the Aalenian deposits of Azerbaijan. In particular, the Lower Aalenian Opalinum zone is defined according to *Leioceras opalinum* Rein., *L. comptum* Rein., *L. götzendorfensis* Dorn., *Costileioceras costosum* Quenst., *Bredya subinsignis* Opp.; the Upper Aalenian Murchisonae zone - according to *Leioceras acutum* Quenst., *L. unicum* Buck., *Staufenia (Costileioceras) sinon* Bayle, *Ludwigia aperta* Buck., *L. murchisonae* Sow., *L. umbilicata* Buck., *L. obtusiformis* Buck.; the Upper Aalenian zone Concavum - according to index-species - *Ludwigia subtilicosta* Krimh. and *Graphoceras rudis* Buck. The level of the last zone is defined in the Jiminskaiya suite deposits as well; it is built of alternating sandstones, aleurolites and argillites, with limestone and conglomerate interlayers in some places. Its existence has been proved by the species *Graphoceras concavum* Sow. and *Ludwigia casta* Buck. [15] attested near the village of Karkhun.

In the Western Caucasus (Russian Federation) the Aalenian deposits, comprising ammonite complexes, crop out in the subzone of the western subsidence of the Main Range zone. In the modern structure the subzone covers the Goitkh anticlinorium and its south-eastern extension up to the Mzimta river basin inclusive. Here, the early elements of the Aalenian ammonites - *Leioceras opalinum* Rein., *L. comptum* Rein. and *Bredya cf. subinsignis* Opp., found along the river Bolshoi Tugups [16], in the middle part of the lower subsuite (up to 1200 m) of the Chataltapin suite, it may be attributed to the Opalinum zone. The lower subsuite is built up by

argillites with several volcanic sheets of average composition and the upper one (400 m) - argillites rarely with aleurolite intercalations. The lower part of the suite in the Mzimta river basin and somewhat to the west is also characterized by ammonites, where in argillites *Costileioceras subcostosum* Buck., *Leioceras cf. bifidatum* Buck. and *L. cf. opalinum* Rein. appear [17].

Deposits of the upper substage of the Aalenian, covering the zone Murchisonae, are allocated mainly on the subsiding part of the Goitkhy anticlinorium (the Ptish and Psekups river basins) constituting the Pshish suite. Its lower part is represented by flyschoid alternation of sandstones, aleurolites and argillites with interlayers of tuffites and basal horizon of clay conglomerates (500), and the upper part is represented by homogeneous argillites with siderite concretions (1000 m). From different levels of the suite are known *Ludwigia cf. murchisonae* Sow., *L. cf. patula* Buck., *L. umbilicata* Buck., *L. attracta* Buck., *Brasilia bradfordensis* Buck. [17, 18], substantiating the presence (here) of the zone Murchisonae.

To the East, the Aalenian deposits discontinuously outcrop within the subzone of the Central Uplift (crystalline core) of the Main Range. In the interfluvium of the rivers Belaya and Baksana, these deposits together with the Lower Cretaceous deposits infill several graben-synclinal depressions. In the western segment, in the Pshexha-Bolshoi Zelenchuk river interfluvium, the Aalenian is represented by the uniform (homogeneous) argillitic strata of the Tubin Suite continuing similar deposits of the Toarcian. The thickness of the deposits covering the Aalenian part of the suite is 800-900m. In the Pshexha river basin the Lower Aalenian comprises *Leioceras opalinum* Rein., *Costileioceras cf. costosum* Quenst. And in the upper horizons *Staufenia (Costileioceras) sinon* Bayle, *Ludwigia obtusiformis* Buck., *L. torta* Buck., *L. cf. patula* Buck. [19] are registered. The noted ammonites attest the presence of Aalenian zones Opalinum and Murchisonae here. The uppermost zone Concavum, apparently, suffered wash-out under the transgressive Bajocian.

The Aalenian deposits with the ammonite species of all zones of this stage are traced in the interfluvium of the rivers Baksan-Psygansu, in the upper part (with maximum thickness 190m) of Jigiat suite. It is built of argillites with siderite concretions and band of sandstones and aleurolites, also interlayers of the concretion conglomerate and clay limestone. From the sediments of the suite *Leioceras opalinum* Rein., *Bredya subinsignis* Opp., *Staufenia (Costileioceras) sinon* Bayle, *Brasilia bradfordensis* Buck. and *Graphoceras concavum* Sow. are known [20].

In the upper subsuite of the Jigiat suite, exposed in East Balkaria (interfluvium of the rivers Chegem and Sekheledon), almost all these ammonite forms, and also *Staufenia (Costileioceras) staufensis* Opp., *St. (C.) sehndensis* Hoff., *L. munchisonae* Sow., *Parammatoceras* cf. *objectum* Buck., are observed; they confirm the presence of the Aalenian zones Opalinum and Murchisonae.

The Aalenian with ammonites of the zones Opalinum and Murchisonae is allocated in clayey-aleuritic strata of the Salgin and Koirakh suites [21, 22] of the interfluvium of the Bezingijsk and Balkar Chereks; they respectively comprise the Early Aalenian *Leioceras opalinum* Rein., *L. cf. thompsoni* Buck. and the Late Aalenian *Staufenia (Costileioceras) cf. sinon* Bayle, *St. (C.) opalinoidea* Mayer and *St. (C.) staufensis* Opp.

In the extreme southeast of the Central Uplift (along the river Ardon) subzone, the ammonites *Leioceras acutum* Quenst. and *Ludwigia tolutaria* Dum. substantiate only the upper substage of the Aalenian (zone Murchisonae) in the deposits of the Koirakh suite.

A relatively rich ammonitic complex, answering all zones of the Aalenian stage, is present in the northwestern part of the External zone of Mountainous Dagestan (interfluvium of the rivers Fiagdon and Assa inclusive). The earliest ammonites of the Aalenian are confined to the deposits of the Sulgin suite represented by argillites and aleurolites with siderite concretions, sometimes with interlayers of concretion conglomerates and sandstones, and marl lenses (the maximum thickness of the suite is from 1000 to 1800m) as well. The main part of the suite is characterized by the ammonites of the Opalinum zone. Particularly: *Leioceras opalinum* Rein., *L. sp.*, *Costileioceras costosum* Quenst., found in the Assa river gorge and *Leioceras* cf. *götzendorfensis* Dorn. from the Terek river gorge, to the north of the Nizhny Lars village [21]. To the Lower Aalenian also belongs the base of overlying sandy-argillaceous strata of the Koirakh suite (thickness of the suite 550-1160m), as here are found representatives of *Leioceras comptum* Rein. Its other part contains [21] *Staufenia (Costileioceras) cf. sinon* Bayle, *Ludwigia tolutaria* Dum., *Hammatoceras sieboldi* Opp. (river Fiagdon); *Staufenia (C.) opalinoidea* Mayer, *St. (C.) sinon* Bayle, *St. (C.) cf. sehndensis* Hoff. (river Armkhi). From the same level in the Assa river valley *Brasilia* cf. *bradfordensis* Buck. and *L. munchisonae* Sow. [23] are marked. We also have found the latter in the Assa river valley [24]. In the Terek river gorge, to the south of the Chmi village, from the upper part of the Koirakh suite are known *Leioceras acutum* Quenst. and *Ludwigia tolutaria* Dum. All the above-mentioned ammonites are index-species allowing to

assert the presence here of the zones Opalinum and Murchisonae. Ammonites of the last upper zone pass into the Fortaukh suite (500-750m) - aleurolites and argillites with interlayers of concretion conglomerates and lenses of marly aleurolite, containing *Staufenia (Costileioceras) cf. sehndensis* Hoff., *St. (C.) sinon* Bayle, *St. (C.) opalinoidea* Mayer (river Armkhi). On the river Terek near the Chmi village in the deposits of the suite are recorded *Staufenia (Costileioceras) sinon* Bayle and *Ludwigia tolutaria* Dum. [21]. To the uppermost layers of the Fortaukh suite on the rivers Armkhi and Assa are confined *Graphoceras* cf. *concovum* Sow. - index-species of the zone with the same name. This zone is characterized also by [24] *Graphoceras cornu* Buck. and *G. sp.* found in the Assa river gorge.

Further the Aalenian deposits crop out in the sections on the Chanty-Argun, Andyan Koisu, Avarian Koisu and Karakoisu, composing here together with the Upper Toarcian Karakh suite. It is mainly represented by massive, thick-layered sandstones with thickness subordinate bands of alternating sandstones, aleurolites and argillites with coal interlayers. The thickness of the suite varies from 1000m in the locality of the river Andyan Koisu up to 2250m on the river Karakoisu. The lower horizons of the suite contain ammonites, establishing the zone Opalinum - *Leioceras comptum* Rein., *L. götzendorfensis* Dorn., *L. opalinum* Rein., *Costileioceras costosum* Quenst. and *Bredya subinsignis* (Opp.). From higher layers are known *Staufenia (Costileioceras) sinon* Bayle, *Leioceras acutum* Quenst., *L. wilsoni* Buck. and *L. munchisonae* Sow., testifying that sediments containing them belong to the lower part of the zone Murchisonae [25].

The Iगतlin suite conformably continues the Karakh suite; it is a rather sustained stratum of alternating argillites, aleurolites and sandstones with the concretions of clay siderite and interlayers of concretion conglomerates (thickness of the suite is 100-700m). The lower part of the suite is - characterized by -*Staufenia (Costileioceras) sinon* Bayle, *St. (C.) staufensis* Opp., *Ludwigia munchisonae* Sow., *L. torta* Buck., *L. bradfordensis* Buck. In the upper part of the suite there appear *Graphoceras concovum* Sow., *G. cornu* Buck., *Ludwigia micra* Buck., -specifying the presence of the uppermost Aalenian zone Concovum.

In the southeast, in the upper reaches of the river Kazikumukh Koisu, in the Iगतlin suite the amount of clay rocks increases, though the sequence of strata does not change. Known from its lower part *Staufenia (Costileioceras) sinon* Bayle, *St. (C.) opalinoidea* Mayer, *Ludwigia munchisonae* Sow., *L. baylii* Buck., and from

the upper - *L. subtilicosta* Krimh., *L. micra* Buck., *Graphoceras cornu* Buck., *G. decorum* Buck., *G. rudis* Buck., *G. concavum* Sow. [25, 3], confirm the presence of standard zones of Aalenian Murchisonae and Concavum.

In the southeastern part of the External zone of Mountainous Daghestan, the Aalenian deposits are developed in the interfluvium of the rivers Uluchai and Kurakhchai. In the uppermost parts of massive - sandstone strata (900 m), that rhythmically alternate with sandy-aleuritic-clay bands of Karakh suite, are met *Ludwigia murchisonae* Sow., *Leioceras acutum* Quenst. The greatest part of the Iगतlin suite contains *Ludwigia murchisonae* Sow. and *L. gracile* Buck., and its upper horizons - *Graphoceras concavum* Sow.

Deposits of the Karakh suite are exposed also on the southern slope of the Samur ridge and in the Samur river basin, where they are a part of the tectonic subzone of the east subsidence zone of the Main Range. They are composed of massive sandstones, frequently alternating with argillites and aleurolites (1600m). From different levels of the suite are taken *Leioceras opalinum* Rein., *Costileioceras costosum* Quenst., *Bredya subinsignis* Opp., *Leioceras acutum* Quenst., *Staufenia (Costileioceras) sinon* Bayle. On Alakhundag pass the Karakh suite contains *Leioceras götzendorfensis* Dorn., *L. wilsoni* Buck., *Costileioceras costosum* Quenst., *Staufenia (Costileioceras) sinon* Bayle, *Ludwigia tolutaria* Dum., *L. murchisonae* Sow. Stratigraphic range of these ammonites specify that the deposits of the Karakh suite, enclosing them, belong to the Aalenian zones Opalinum and Murchisonae. The last form and *Staufenia (Costileioceras) sinon* Bayle are observed also in argillites, alternating with aleurolites and sandstones of the Karakh suite on the left bank of the river Samur [25].

To the northwest the Aalenian deposits are traced in the interfluvium of the rivers Belaya and Chegem; here they are confined to the Pshekysh-Tirniauz suture zone. In its eastern - part, in the interfluvium of Chegem-Baksan the Aalenian covers the upper subsuite of Jigiat suite (argillites with intercalations of aleurolites, fine-grained sandstones and concretion conglomerates - thickness 100-700 m) with ammonites *Leioceras opalinum* Rein., *Staufenia (Costileioceras) sinon* Bayle and *Brasilia bradfordensis* Buck., dating them as early and late Aalenian. The Uppermost horizons of Aalenian, represented by lenticular bands of sandstones and conglomerate-breccias, comprise *Graphoceras concavum* Sow. This regressive band refers to the top of the Upper Aalenian and the lowermost Bajocian [26]. In the western termination of the tectonic zone, in the Belaya river

basin, the Aalenian deposits are characterized only by one, not defined to a species, Late Aalenian ammonite *Ludwigia* sp.

Finally, the last exits of the Aalenian are uncovered in the Laba-Malka zone. In its western part, in the Belaya, Bolshaya and Malaya Laba river basins, they are allocated under the name of Tubin suite [27] of Late Toarcian-Aalenian age. It is represented by argillites enclosing siderite and pyrite concretions. Interlayers of sandstones and aleurolites (thickness of the suite is 400-800m) are observed seldom. Its Aalenian part at different levels contains *Leioceras opalinum* Rein., *L. comptum* Rein., characteristic of the zone Opalinum, and also - *Ludwigia subcasta* Rost., *Brasilia bradfordensis* Buck., *B. ex. gr. tutcheri* Buck., their stratigraphic range is restricted to the zone Murchisonae.

More to the east, in the Urup, Bolshoi and Maly Zelenchuk and Kuban river basins, the Tubin suite is replaced by the deposits of Jigiat suite. In the upper part of the suite (42m), corresponding to the Aalenian stage, are traced clays with layers of siderite concretions. In the suite there appear interlayers of fine-grained clay sandstones and conglomerates resting on the underlying deposits with slight washout. The lower horizons of the upper part of the Jigiat suite comprise the zone Opalinum, substantiated by index-species - *Leioceras comptum* Rein., *L. substriatum* Buck., *L. götzendorfensis* Dorn., *Costileioceras costosum* Quenst., *C. Cariniferum* Buck. The overlying zone Murchisonae contains a complex in a quantitative sense considerably rich in ammonites, in particular, *Leioceras wilsoni* Buck., *Ludwigia baylei* Buck., *L. lateocostata* Althoff, *L. obtusififormis* Buck., *L. schoanensis* Rost., *L. subcasta* Rost., *L. imbilicata* Buck., *Brasilia bradfordensis* Buck. *B. gigantean* Buck., *B. tutcheri* Buck. (27).

In the Kardonic and Kuban river-basins the Murchisonae zone is also represented by numerous characteristic species- *Staufenia (Costileioceras) sinon* Bayle, *Leioceras wilsoni* Buck., *L. decipiens* Buck., *L. acutum* Quenst., *L. helveticum* Horn., *L. unicum* Buck., *L. uncinatum* Buck., *Ludwigia murchisonae* Sow., *L. haugi* Duvil., *L. tuberculata* Buck., *L. tolutaria* Dum., *L. obtusa* Quenst., *Brasilia bradfordensis* Buck., found in sandstones and siderite concretions (10m).

In the sections of the same basins is established the upper zone of the Aalenian stage Concavum., more restricted in distribution than the previous zones. It is allocated by *Ludwigia casta* Buck., *L. excavate* Buck., *L. aspera* Buck., *L. lucyi* Buck., *L. rugosa* Buck. and *Graphoceras decorum* Buck. (1,2), and also *Ludwigia subtilicosta* Krimh. and *Graphoceras concavum* Sow. [28].

The presence of all the three Aalenian zones is possible to be confirmed even in more eastern outcrops of the upper subsuite (116m) of the Jigiat suite that has developed in the Malka-Baksan interfluve. To the middle part of the subsuite, represented mainly by argillites, are confined *Leioceras opalinum* Rein., *Costileioceras costosum* Quenst., to the upper part - *Leioceras wilsoni* Buck., *Ludwigia munchisoni* Sow., *L. baylei* Buck., *L. subcasta* Rost., *L. umbilicata* Buck., *Brasilia bradfordensis* Buck., and to the uppermost layers *Graphoceras* ex. gr. *concovum* Sow.

### 3. Conclusions

The study of the distribution of ammonite fossils from the Aalenian deposits in different regions of the Caucasus shows that their quantity grows gradually from south to north and, as a consequence, in the same direction, the biostratigraphic zones are more and more completely and reliably substantiated by the zonal complexes. In the southern outcrops of the Aalenian deposits within the Azerbaijanian and Georgian parts of the Liki-Karabakh tectonic zone, the lowermost zone Opalinum is confirmed by only a few ammonites, and the presence of the overlying zone Murchisonae is established by a

single index-species found in the territory of Georgia. To the north, within the Southern Slope of the Greater Caucasus, in the Kazbegi-Lagodekhi zone, Aalenian ammonite complexes become more numerous. Here, the Lower Aalenian zone, both in Georgia and Azerbaijan, is substantiated by ammonites, very similar in species composition. As for the overlying zone Murchisonae, it is, in both regions, represented by zonal complexes somewhat different from each other. The uppermost zone of the Aalenian stage (Concovum) is established only in Azerbaijan, whereas in Georgia it is completely devoid of archistatigraphic species.

Considerably more various and rich ammonite complexes characterizing all the Aalenian zones are developed in the Northern Caucasus (Russian Federation). Among them, there are zones known on the territory of Georgia and Azerbaijan as well.

The vertical distribution of ammonites in the Caucasus is generally very similar to that in Western Europe. The common specific and generic composition of Aalenian ammonites gives evidence that the Caucasus and Western Europe belong to the same faunal province. At the same time, there are some differences caused by the absence or scarcity of some zonal species in the ammonite fossils of the Caucasus.

## გეოლოგია

# კავკასიის აალენური ნალექების ზონური დანაწილება ამონიტების მიხედვით

## მ. თოფჩიშვილი

აკადემიის წევრი, ა.ჯანელიძის გეოლოგიის ინსტიტუტი, თბილისი

კავკასიის სხვადასხვა რაიონის ჭრილებიდან მოპოვებული და არსებული მდიდარი პალეონტოლოგიური მასალის საფუძველზე, რომელიც წარმოდგენილია გეოლოგიისათვის უმნიშვნელოვანესი თავფეხიანი მოლუსკური ფაუნის ჯგუფით (ამონიტებით), შემუშავდა ამ რეგიონის აალენური ნალექების ზონური დანაწილების სქემა.

კავკასიის და დასავლეთ ევროპის აალენური ამონიტების ზონური კომპლექსების შედარებამ გვიჩვენა, რომ მათ შემადგენლობაში მრავალი საერთო გვარი და სახეობაა. ეს გარემოება საშუალებას გვაძლევს დაფასვენათ, რომ დასავლეთ ევროპა და კავკასია ერთ ფაუნისტურ პროვინციას მიეკუთვნება.



## REFERENCES

1. *E.E. Migachova* (1957), DAN SSSR, **113**, 3: 653-656 (in Russian).
2. *K.O. Rostovtsev* (1962), Izvestiya AN SSSR, Ser. Geol., **12**: 46-60 (in Russian).
3. *V.P. Kazakova* (1984), Aalenskii yarus, ego zonal'noe raschlenenie i granitsy. M.: 193 pp. (in Russian).
4. *V.B. Agaev, T.A. Gasanov* (1970), Uchebnye zapisi Azerbaidzhanskogo Universiteta. Ser. Geol.-geograph., **3**: 47-51 (in Russian).
5. *M.V. Topchishvili* (1996), Trudy Geolog.Inst. AN Gruzii. Novaya seriya, vyp. **108**. Tbilisi: 216 pp. (in Russian).
6. Trudy MSK (1982), vol. **10**, Leningrad: 191 pp. (in Russian).
7. *I.P. Gamkrelidze* (1984), Trudy GIN AN GSSR, Novaya seriya, vyp. **86**: 105-184 (in Russian).
8. *I.P. Gamkrelidze* (2000), Trudy GIN AN Gruzii. Novaya seriya, vyp. **115**: 204-208 (in Russian).
9. *K.O. Rostovtsev, E.L. Prozorovskaya, B.I. Vuks, V.S. Belenkova* (1985), Yurskie otlozheniya yuzhnoi chasti Zakavkaz'ya. L.: 188 pp (in Russian).
10. *T.A. Gasanov* (1977), Geologiya Azerbaidzhana - Stratigrafiya, vol. 1. Baku: 57-73 (in Russian).
11. *K.E. Gabunia, P.D. Gamkrelidze* (1942), Trudy GIN AN GSSR, Geol. series, vol. **1(VI)**: 5-72 (in Georgian).
12. *V.I. Zesashvili* (1967), Trudy GIN AN GSSR, Novaya seriya, vyp. **15**: 5-25 (in Russian).
13. *A.I. Janelidze* (1946), Soobshcheniya AN GSSR, VII, 5: 253-254 (in Russian).
14. *V.B. Agaev* (1997), Geologiya Azerbaidzhana – Stratigrafiya. Geol. Inst. Azerb. AN: 43-51 (in Russian).
15. *V.B. Agaev* (1990), Stratigrafiya Yurskikh otlozhenii Azerbaidzhana (Bol'shoi Kavkaz). Baku: 164 pp. (in Russian).
16. *K.O. Rostovtsev* (1992), Trudy mezhdedomst. stratigraf. komiteta, vol. 22. St.-Petersburg: 46-50 (in Russian).
17. *K.O. Rostovtsev* (1992), Trudy Krasnodarskogo filiala VNII, Issue **12**: 73-112 (in Russian).
18. *K.O. Rostovtsev* (1992), Trudy mezhdedomst. stratigraf. komiteta, vol. 22. St.-Petersburg: p.16-19 (in Russian).
19. *K.O. Rostovtsev* (1967), Izvestiya AN SSSR. Ser. Geol., **2**: 95-108 (in Russian).
20. *D.I. Panov, N.V. Beznosov* (1992), Trudy mezhdedomst. stratigraf. komiteta, vol. 22, St.-Petersburg.: p.31-33 (in Russian).
21. *D.I. Panov* (1997), Bull. MOIP. Sect. geol., **72**, 5: 46-55 (in Russian).
22. *D.I. Panov* (2003), Stratigraphy. Geological correlation, **11**, 1: 64-77 (in Russian).
23. *M.M. Matskevich* (1964), In: Geologiya i neftegazonosnost' vostochnogo Predkavkaz'ya – Trudy Grozn. Neft. NII, vyp. **17**, M.: 39-55 (in Russian).
24. *M.V. Topchishvili* (1988), Soobshcheniya AN GSSR, **130**, 1: 113-116 (in Russian).
25. Ob'yasnitel'naya zapiska k stratigraficheskoj skheme Yurskikh otlozhenii severnogo Kavkaza (1973), M.: 194 pp. (in Russian).
26. *D.I. Panov* (1976), In: Geologiya Bol'shogo Kavkaza. M: 154-207 (in Russian).
27. *K.O. Rostovtsev, D.I. Panov, N.V. Beznosov* (1992), Trudy mezhdedomst. stratigraf. komiteta, vol. 22, St.-Petersburg: p. 19-25 (in Russian).
28. *I.R. Kakhadze, A.L. Tsagareli, K.Sh. Nutsubidze, V.I. Zesashvili* (1960), Geologicheskoe stroenie polosy uglenosnykh otlozhenii mezhdou basseinami rek Baksan i Urup. Tbilisi: 139pp. (in Russian).

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