

Ammonite associations and biostratigraphy of the Middle Jurassic sediments of Georgia

Asociaciones de ammonoideos y bioestratigrafía de las sucesiones del Jurásico Medio de Georgia

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ABSTRACT

The Middle Jurassic deposits are developed in all the major tectonic units of Georgia. Each of these units are characterized by specific lithofacies containing rich assemblages of ammonite fauna. On the basis of index - ammonites assemblages within the Middle Jurassic deposits the Aalenian, Bajocian, Bathonian and Callovian stages have been recognized. The stages, in turn, are subdivided into substages and zones of the general standard scale and, in some cases, into regional zones as well.

Key-words: Aalenian, Bajocian, Bathonian, Callovian, Georgia, ammonites, biostratigraphy.

RESUMEN

En Georgia, los materiales del Jurásico Medio se encuentran desarrollados en la totalidad de las principales estructuras tectónicas. Cada una de estas uni-

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dades está caracterizada por una litofacies característica que en general suele contener asociaciones ricas en Ammonoideos. El análisis de las sucesiones de ammonoideos ha permitido caracterizar los pisos Bajociense, Bathoniense, y Calloviense. A su vez, estas unidades cronoestratigráficas han podido ser subdivididas en subpisos y zonas dentro de la escala cronoestratigráfica estandar y, en ciertos casos, también en zonas de alcance regional.

Palabras clave: Aalenienense, Bajociense, Bathoniense, Calloviense, Georgia, ammonites, bioestratigrafía.

INTRODUCTION

The Middle Jurassic sediments are playing a significant role in the geological structure of Georgia. They are widespread within the Fold system of the Greater Caucasus, in the Transcaucasian intermontane depression (Georgian block) and in the Lesser Caucasus (the Locki and Khrami massifs) (Fig.1). Often they host important mineral deposits and for a long time have attracted the attention of many authors.

In Georgia Middle Jurassic deposits are represented by various facies - deep-sea marine, epicontinental, lagunal and volcanogenic-terrigenous. These deposits contain a large amount of ammonite which are the base for biostratigraphic differentiation of the Middle Jurassic in Georgia. The presence of characteristic species allows us to recognize zones of the standard scale. However, ammonites are distributed unevenly both in the sections and across the area: Sometimes, only occasional representatives have been encountered. In these cases we can speak only about the presence of either zone.

AALENIAN

Aalenian sediments of Georgia are developed in the eastern part of the Main Range zone, in the southern slope of the Fold system of the Greater Caucasus (Kazbegi-Lagodekhi, Chkhalta-Laila and Gagra-Djava structural-facial zones) (Fig. 1), within the uplifted portion of the Georgian block (Dzirula massif) and in the Lesser Caucasus - in the Locki and Khrami massifs. Here, they conformably overlie the Toarcian rocks, and in turn, gradually, but sometimes unconformably, with traces of outwash, pass into Bajocian formations.

Most reliably the Aalenian deposits are substantiated by ammonites in the Kakhetian part of the Kazbegi-Lagodekhi structural-facial zone where they are mainly composed of shales and argillites with subordinate interlayers of sandstones and numerous concretions of clayey siderite (total thickness up to 1100 m). The lower horizons of this sequence contain *Tatrophylloceras* cf. *tatricum* (Pusch), *Calliphylloceras* cf. *dzirulensis* (Djan.), *Leioceras opalinum*

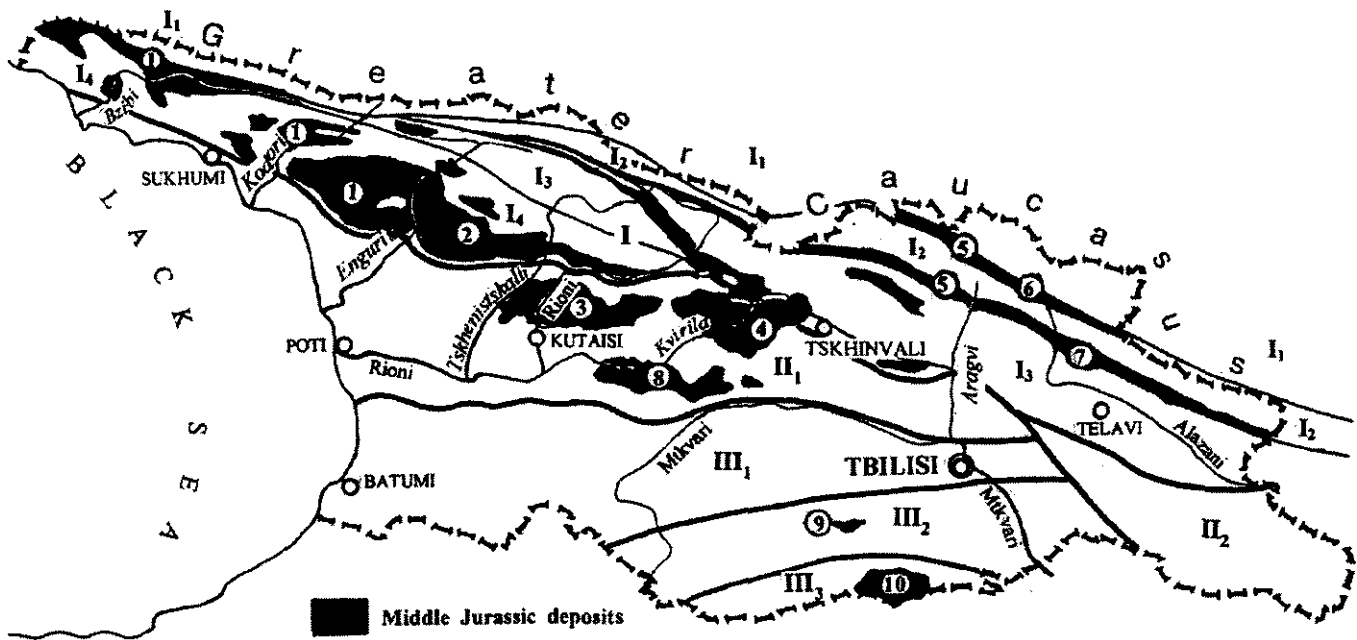


FIG. 1.—Geographic situation of the Middle Jurassic outcrops in Georgia. I - Fold system of the Greater Caucasus: I₁ - Main Range zone; I₂ - Kazbegi-Lagodekhi zone; I₃ - Chkhalt'a-Laila zone; I₄ - Gagra-Djava zone; II - Transcaucasian intermontane depression: II₁ - Georgian block; II₂ - Kura intermontane basin; III - Fold system of the Lesser Caucasus; III₁ - Adjara-Trialetian fold zone; III₂ - Artvin-Bolnisi block; III₃ - Locki-Karabakhi zone. 1 - Abkhazia, 2 - Svaneti, 3 - Racha, 4 - Tskhinvali region, 5 - Khevsureti, 6 - Tusheti, 7 - Kakheti, 8 - Dzirula Massif, 9 - Khrami Massif, 10 - Locki Massif.

FIG. 1.—Situación geográfica de los afloramientos de Jurásico Medio en Georgia. I - Sistema de plegamientos del Gran Cáucaso: I₁ - Zona de la Cordillera Principal; I₂ - Zona de Kazbeghi-Lagodekhi; I₃ - Zona de Chkhalt'a-Laila; I₄ - Zona de Gagra-Djava. II - Depresión Intramontana Transcaucásica: II₁ - Bloque Georgiano; II₂ - Cuenca intramontana de Kura; III - Sistema de plegamientos del Pequeño Cáucaso: III₁ - Zona de plegamiento de Adjara-Trialet; III₂ - Bloque de Artvin-Bolnisi; III₃ - Zona de Locki-Karabakhi. 1 - Abkhazia; 2 - Svaneti; 3 - Racha; 4 - Región de Tskhinvali; 5 - Khevsureti; 6 - Tusheti; 7 - Kakheti; 8 - Macizo de Dzirula; 9 - Macizo de Khrami; 10 - Macizo de Locki.

(Rein.), *L. gotzendorfensis* (Dorn.), *L. comptum* (Rein.), *Costileioceras costosum* (Quenst.), *C. subcostosum* (Buck.) and *Bredya* cf. *subinsignis* (Opp.). Most of these forms indicate early Aalenian Opalinum Zone.

The Middle Aalenian is identified within the more upper horizons of shales that is confirmed by the find of *Costileioceras costatum* (Horn), *Ludwigia* sp., *L. obtusifformis buckmani* Gec., *Brasilia bradfordensis* (Buck.) and *B. sublineata* Buck. These fauna allow to correlate enclosing rocks with the Murchisonae (Topchishvili, 1996) and Bradfordensis Zones.

To the northwest, in Khevsureti the composition of the Aalenian somewhat changes. Its lower part (350 m) is dominated by medium- and thick-layered, fine- and middle-grained sandstones. They often contain fragments of shales and are distinguished by cross-bedding texture. Shales, as thin layers and intercalations occur here in insignificant amount. These deposits contain Early Aalenian *Leioceras opalinum* (Rein.) and *Costileioceras* cf. *costosum* (Quenst.). As to the Upper Aalenian it includes the overlying sequence (500 m) represented by shales devoid of ammonites.

Somewhat westward, in the vicinity of the Chaukhi massif, tholeiitic basalts appear among shales in the form of pillow lavas, pillow lava breccias and hyaloclastics. Directly beneath the volcanic - terrigenous rocks contain *Lytoceras* sp. and *Leioceras* cf. *opalinum* (Rein.).

In the western termination of the Kazbegi-Lagodekhi zone (Northern Svaneti and Racha) Aalenian is mainly composed of shales with *Leioceras* cf. *opalinum* (Rein.) and *Costileioceras costosum* (Quenst.).

In the eastern part of the Main Range zone, within Northern Khevsureti and Tusheti the Aalenian is represented by shales and sandy-aleurolitic shales with subdued intercalations of fine-grained sandstones and concretions of clayey siderite (up to 800 m thick). The sequence contain *Leioceras* sp., *L. opalinum* (Rein.), *Costileioceras* sp., *C. costosum* (Quenst.), *C. cf. subcostosum* (Buck.) and *Ludwigia* sp. ind.

The proportion of sandstones to shales considerably changes in the southern part of the southern slope of the Greater Caucasus, within the Gagra-Djava zone that extends along the northern border of the Georgian block. In this region the Aalenian is made up of flyschoid thin, middle - and, mainly, thick-bedded sandstones alternating with argillites (up to 900 m). The sandstones are characterized by frequent flysch hieroglyphs. Varying in granulometry they locally pass into conglomerates. Shales contain charred floral detritus and ammonites: *Leioceras opalinum* (Rein.), *L. comptum* (Rein.), and *Costileioceras costosum* (Quenst.), which date the Early Aalenian (Topchishvili, 1986). However, there remains enough place between beds with early Aalenian fossils and Bajocian deposits to admit here the presence of middle and upper Aalenian as well.

In the Dzirula massif the terrigenous deposits are replaced by the facies of «Ammonitico rosso» represented by red organogenic limestones with *Costileioceras* cf. *costosum* (Quenst.), «*Hammatoceras*» *tenuinsigne* Vac. and *Ery-*

cites sp. nov. According to these ammonites the limestones (10-14 m thick) correspond only to lower Aalenian. Its upper part is here washed out by the Bajocian transgression.

Southwards, on the peripheries of the Locki and Khrami massifs (the Lesser Caucasus) Aalenian is represented by terrigenous rocks - argillites, intercalated with aleurolites and fine-grained sandstones with sideritic concretions (150 m). On the western margin of the Locki massif, gravelstones, conglomerates and coarse-grained quartz sandstones appear in the upper levels. From the argillites of the Locki massif *Costileioceras* cf. *costosum* (Quenst.), *Ludwigia purchisonae* (Sow.) and *Bredya subinsignis* (Opp.) have been collected.

BAJOCIAN

The Bajocian deposits outcrop in the southern slope of the Fold system of the Greater Caucasus, on the Georgian block and in the Lesser Caucasus.

Within the southern slope the Bajocian deposits form two bands of the so-called «caucasian», NW-SE, strike. The northern one located along the watershed ridge of the Greater Caucasus is composed of terrigenous facies (shales and sandstones) nearly completely devoid of ammonites, whereas the southern one adjacent to the northern margin of the Georgian block mainly consists of andesitic-basaltic volcanic rocks known as the porphyritic series.

Deposits of the southern band outcropping in Svaneti and Racha are distinguished by a very large thickness - up to 2500-3000 m. Their lower horizons are composed of Porphyritic tuff-breccias, tuff-sandstones alternating with shales, the upper ones - of tuff-breccias with porphyritic flows and rare intercalations of shales. In Svaneti, in the middle reaches of the Inguri river, tuff-breccias and volcanogenic rocks of the upper part of the porphyritic series contain *Eurystomiceras polyhelictum okribense* Kakh. and *Parkinsonia* cf. *parkinsoni* (Sow.). At the same level in Abkhazia there have been found *Pseudophylloceras* cf. *kudernatschi samtshikensis* Kakh., *Dinolytoceras adela* (d'Orb.), *Nannolytoceras stremoukhovi* Pchel., *Parkinsonia compressa* (Quenst.).

Not long ago Bajocian volcanic rocks were established also farther north, in Kakhetian part of the Kazbegi-Lagodekhi zone (Avalishvili *et al.*, 1974). This volcano-sedimentary complex (800 m thick) takes part in the construction of a syncline structure 3,2 km long and 2,5 km wide. In the northern limb of this fold Bajocian lies on Aalenian deposits, whereas along the southern limb Bajocian has tectonic contact with the Upper Jurassic carbonate flysch. Here Bajocian is represented by shales with flows of spilitic porphyrites. The upper horizons of this sequence are formed by tuff-breccias of the spilitic composition. Shales from the lower levels contain *Hyperlioceras* sp., *Euhoploceras crassispinatum* (Buck.) and *Brasilia* aff. *bradfordensis* (Buck.).

The stratigraphic range of ammonites met in the northern limb of the syn-

cline indicate their mixed character, i.e. genera *Hyperlioceras* and *Euhoploceras* are related to the early Bajocian, whereas the *Brasilia* genus representatives are common in middle Aalenian. It is likely that the occurrence of *Brasilia* aff. *bradfordensis* (Buck.) among renovated ammonite gives evidence of its relict character.

Within the Georgian block Bajocian deposits are exposed in its most uplifted part in the Dzirula massif and adjacent areas. On the southern and north-western margins they transgressively overlap the crystalline rocks of the Paleozoic basement and different horizons of red organogenic limestones of the Lower Jurassic and Aalenian. On the northeastern margin the Bajocian gradually replaces Aalenian flyschoid sediments.

On the southern margin of the Dzirula massif the Bajocian is composed of tuff-breccias, tuff-sandstones, tuffs and flows of porphyrites of total thickness more than 1500 m. The lower horizons of this sequence contain bivalvia and ammonites: *Phylloceras* ex gr. *heterophylloides* (Opp.), *Skirroceras freycineti* (Bayle), *S.* cf. *zietenii* (Quenst.), *Otoites contractus* (Sow.), *Emileia polyschides* (Waag.).

The fauna of the northeastern margin is distributed through the section as follows (Kakchadze, 1947):

1. Massive and thick-bedded tuff-breccias alternating with thin flows of porphyrites - 160 m.

2. Thin-bedded tuffs, tuff-sandstones and microconglomerates with *Holcophylloceras zignodianum* (d'Orb.), *H. raricostatum* Kakh., *Lytoceras tschonthense* Kakh., *Skirroceras freycineti* (Bayle), *Stephanoceras dzirulensis* Kakh. - 42m.

3. Tuffs and tuff-sandstones with arcose conglomerate and breccia beds. At the base of this unit there have been found *Phylloceras wermediae* Kakh., *Eurystomiceras polyhelictum* (Bockh.), *Stephanoceras humphriesianum* (Sow.), *Normannites braikenridji* (Sow.) - 95 m.

4. Alternation of medium-bedded tuff-breccias, tuffs and fine-grained tuff-sandstones with *Garantiana* cf. *bifurcata* (Ziet.) - 21 m.

Tuff-sandstones interbedded with shales (100 m) which are developed at the upper horizons of the Porphyritic suite in Tskhinvali region contain *Partschiceras abichi* (Uhl.), *Parkinsonia* cf. *parkinsoni* (Sow.) and *P.* cf. *depressa* (Quenst.).

The deposits of Bajocian Porphyritic suite are widespread to the NE of the Dzirula massif, in the Okriba uplift of the Georgian block. Here they are best characterized by ammonites in the basin of the Tskhenistskali river where the following succession of rocks is observed:

1. Massive coarse tuff-breccias with augite-labradorite porphyritic flows. The different levels of this sequence are characterized by *Holcophylloceras me-*

diterraneum (Neum.), *Calliphyloceras* aff. *heterophylloides* (Opp.) and *Emileia polymera* (Waag.) - 500 m.

2. Stratified small-pebbled tuff-breccias with *Holcophylloceras zignodianum* (d'Orb.), *Lytoceras tshonthense* Kakh., *Stephanoceras pyritosum* (Quenst.) - 60 m.

3. Fine- and middle-grained tuff-sandstones with *Holcophylloceras mediterraneum* Neum., *Garantiana* aff. *baculata* (Quenst.) - 100-150 m.

4. Alternation of thin-bedded tuff-breccias with sandstones, in places tuffogenic, containing *Holcophylloceras* aff. *zignodianum* (d'Orb.), *Eurystomiceras polyhelictum okribense* Kakh., *Oppelia subradiata* (Sow.), *Parkinsonia depressa crassa* Nicol., *Ocribites djanelidzei* Kakh. - 120-200 m.

5. Fine - and middle-grained tuffs with *Garantiana baculata* (Quenst.) - 40 m.

These deposits are overlain by the Upper Jurassic rock. From the Tskhe-nistskali river valley volcanogenic rocks extend toward the valley of the Rioni river. Here they are represented by coarse- and small- pebbled tuff-breccias, tuffs and tuff-sandstones with augite-labradorite porphyritic flows (2500 m).

From the lower part of this thick sequence the following ammonites have been collected: *Partschiceras abichi* (Uhl.) and *Lytoceras tshonthense* Kakh., and from the upper layers - *Holcophylloceras rionense* Djan., *Eurystomiceras polyhelictum okribense* Kakh., *Parkinsonia* sp. aff. *planulata* (Quenst.), *Ocribites okribensis* Kakh., *Garantiana garantiana* (d'Orb.) (Kakchadze, 1947).

In the tuffs of porphyritic andesites of the Rioni basin Vakhania (1976) also points out the presence of *Partschiceras vermediae* Kakh., *Eurystomiceras polyhelictum* (Bockh.), *Lytoceras tshonthense* Kakh. and *Stephanoceras* cf. *humphriesianum* (Sow.). A little higher, *Parkinsonia depressa* (Quenst.) and *P. subarietis* (Wetz.).

In the eastern part of Okriba the upper horizons of volcanogenics often include beds of slaty micaceous sandstones and shales. Their late Bajocian age (Parkinsoni Zone) is substantiated by the find of *Parkinsonia djanelidze* Kakh., *P. orbigniana* (Wetz.), *P. subarietis* (Wetz.), *P. depressa crassa* (Nic.), *Oppelia subradiata* (Sow.).

In north Okriba the Bajocian again is entirely composed of volcanogenic rocks. In particular, here there is an alternation of tuff-breccias and tuff-sandstones with rare porphyritic flows and fragments of *Eurystomiceras eudesianum* (d'Orb.), *Stephanoceras vaniense* Kakh. The overlying tuff-sandstones reveal the renovation of fossils. Here there appear *Pseudophylloceras kudernatschi* (Hauer), *Partschiceras abichi* (Uhl), *Eurystomiceras polyhelictum okribense* Kakh., *Parkinsonia depressa* (Quenst.), *P. djanelidze* Kakh., *P. planulata* (Quenst.), *Garantiana* cf. *garantiana* (d'Orb.).

To the south of the Georgian block bajocian sediments are developed in the Lesser Caucasus within the Locki massif. On the northern and western margins

of the massif they are exposed as small outcrops. Comparatively more fully volcanogenic rocks characterized by ammonites are developed along the southeastern margin of the massif. According to Zesashvili (1955), the porphyritic series is subdivided into three units. The lower unit (1700 m) is made up of massive porphyrites and their pyroclastic with *Calliphylloceras heterophylloides* (Opp.); the middle one (350 m) is represented by bedded tuff-breccias and tuff-sandstones with the prevalence of aleurolites and sandstones at the base and with floral debris and *Pseudophylloceras* cf. *kudernatschi* (Hauer.), *Partschiceras* cf. *abichi* (Uhl.) *Eurystomiceras polyhelictum* (Bockh.), *Vermisphinctes martinsi* (d'Orb.), *Parkinsonia* cf. *parkinsoni* (Sow.) and *Oppellia subradiata* (Sow.). The upper unit (1000 m) consists of andesitic quartz porphyrites and their pyroclastics with *Vermisphinctes martinsi* (d'Orb.).

BATHONIAN

In Georgia marine Bathonian deposits have limited distribution in comparison with Bajocian rocks. They are developed in the southern slope of the Greater Caucasus (West Abkhazia, Racha, Tskhinvali region) and in the Lesser Caucasus (Locki massif). In the Western Georgia (Abkhazia) Bathonian sandy beds are exposed in the gorges of the Psow, Gega, Bzibi and some other rivers.

One of the characteristic sections is located at the village Pskhu, in the canyon of the Betaga river (the right tributary of the Bzibi). At present, Bathonian and similar deposits are identified as «the Betaga suite».

In the canyon of the Betaga, just as in other regions of Abkhazia, above the tuff-breccias and argillites of Bajocian conformably occur (Kachadze, 1947; Tsereteli, 1968, 1989; Paichadze, 1978) sandy aleurolites and graywacke sandstones intercalated by dark sandy limestones. The deposits contain frequent limestone concretions, floral debris, thin coal lenses and shells of various molluscs - 200 m. Here, as well as, in the vicinity of the villages Pskhu, Rigza and others the following ammonites have been found: *Calliphylloceras disputabile* (Zit.), *Pseudophylloceras* cf. *kudernatschi* (Hauer), *Partschiceras striatoplicatum* Besnos., *Nannolytoceras ilanense* (Strem.), *Oecotraustes* (*Paroecotraustes*) ex-gr. *fascus* (Quenst.), *Oxycerites yeovilensis* Roll., *Cadomites* cf. *orbigny* Gross. The majority of mentioned ammonites have wide vertical range from Bajocian to Callovian inclusive. The only exception is *Oxycerites yeovilensis* Roll. - a characteristic species of the Zigzag Zone.

The beds attributed to the Betaga suite are transgressively overlapped by Callovian deposits which in most cases are characterized by ammonites.

To the east of Abkhazia, in Racha, marine bathonian deposits are known in the middle reaches of the Rioni river. In this area bajocian volcanics are transgressively, with basal conglomerates, overlain by late Bathonian shales. The latter gradually, without any traces of gap, pass into sandy deposits of Callovian (Khimshiashvili, 1957; Lominadze, 1982). The only section where ammonites

were found is at the v. Tsesi (the Rioni river). Here above bajocian volcanics occur:

1. Dark and black shales with calcareous concretions and thin-bedded carbonate sandstones. There are numerous floral debris, less frequently shells of bivalvia and occasional ammonites: *Hemigarantia julii* (d'Orb.), *Oecotraustes* (*Pseudoecotraustes*) *bifurcus* Khim., *Lissoceras* sp. indet., *Pseudoperisphinctes* sp. indet. - 25 m.

2. Greenish-grey sandstones with concretions (containing fragments of bivalvia) and intercalations of clayey sandstones - 30 m.

3. Alternation of thin- and thick-bedded sandstones with concretions. The rocks contain shells of bivalvia and rare representatives of *Phylloceras* - 30 m.

The distribution of Middle Jurassic deposits is confined by the gorge of the Rioni river. The upper horizons of this section are exposed on the left bank of the river and at the v. Tsesi, where they are characterized by the rich Callovian ammonite content.

The shales (layer 1) situated between bajocian volcanics and callovian sandstones (layers 2 and 3) were assigned by earlier investigators to Callovian. However, the discovery of zonal index *Hemigarantia julii* (d'Orb.) in the layer I (determination of Paichadze) undoubtedly points to the late Bathonian age of the host shales.

Eastward, in the upper reaches of the Kvirila river (Tskhinvali region) Bathonian beds are developed on the limited area. The most characteristic section is near the v. Tsona.

Here over the bajocian volcanic rocks occur:

1. Conglomerates of porphyritic and tuffogenic sandstone pebbles - I - 4 m.

2. Rusty-brown bedded fine-grained sandstones and sandy clay with concretions. Both deposits and concretions contain floral detritus, Bivalvia and Cephalopoda -35-40m.

3. Bedded calcareous sandstones and sandy limestones - 20 m.

The clayey-sandy beds (layer 2) contain numerous ammonites: *Oecotraustes* (*Paroecotraustes*) *maubeugei* Steph., *Oecotraustes* (*Paroecotraustes*) *densicostatus* Liss., *Eohecticoceras* (*Eohecticoceras*) *haugi* (Pop.-Hatr.), *E.* (*E.*) *tsonenensis* (Khim.), *Oppelia* (*Alcidia*) *fuscoides* Kuhn, *O.* (*A.*) *subcostaria* (Oppel), *Cadomites* (*Cadomites*) *bremeri* Tser., *C.* (*Polyplectites*) *ertsoensis* Paitch., *C.* (*P.*) *zlatarskii* Steph., *Bullatirnorphites* (*Bullatimorphites*) *latecentratus* (Quenst.), *B.* (*B.*) aff. *perisphinctoides* Ark., *Siemiradzka* (*Siemiradzka*) *caucasica* Steph., *S.* (*Prevalia*) *pseudoperspicua* Steph., *Homoeoplanulites* (*Parachoffatia*) cf. *funatus* (Opp.), *Flabellisphinctes* aff. *villanyensis* (Till.), *Choffatia* (*Grossouvria*) *curvicosta* (Opp.), *C.* (*Choffatia*) *evoluta* (Neum.) and numerous Phylloceratidae (Tsereteli, 1968, 1989; Paichadze, 1973).

Previous authors attributed layers 1 and 2 to Callovian. However, fossils found by us indicates the middle and late Bathonian age of these rocks (the Bremeri and Retrocostatum Zones).

Among all the described forms the most interesting is *Cadomites (C.) bremeri* Tser. This species has limited stratigraphic range and is used as an index-species for the upper part of middle Bathonian (Kopic, 1974).

Considerable place in the fossil assemblage belongs also to representatives of the *Oecotraustes* and *Eohecticoceras* genera several species of which - *Oecotraustes (Paroecotraustes) maubeugei* Steph., *O. (P.) densicostatus* Liss., *Eohecticoceras (Eohecticoceras) haugi* (Pop.-Hatz.) and others reached their greatest flourishing in late Bathonian (the Retrocostatum Zone).

Marine bathonian deposits are also developed in the Lesser Caucasus, in the Locki-Karabakhi zone. In the upper reaches of the rivers of Gulmagometchai and Uianovskiskhevi volcanogenic-terrigenous upper Bajocian rocks are exposed above which conformably lie:

1. Argillites and shales with intercalations of sandstones and gravelstones (Ze-Sashvili et al., 1977). In the upper part of this unit were met floral detritus, bivalves and ammonites: *Morphoceras (Ebrayiceras) filicosta* Wetzel, M. (E.) *sulcatum* (Zeit.), *M. (Morphoceras) multiforme* Ark., *Oxycerites limosus* (Buckm.), *Oxycerites yeovilensis* Roll, and *Lissoceras psilodiscus* (Schl.) - 80m.

2. The described rocks are transgressively, with basal conglomerates at the sole, overlain by volcanogenic-terrigenous rocks whose stratigraphic position corresponds to Callovian.

Assemblages of fossils given in layer 1 undoubtedly indicate early Bathonian. Representatives of the *M. (Morphoceras)* and *M. (Ebrayiceras)* genera are characteristic for the whole early Bathonian whereas *Oxycerites yeovilensis* Roll, is considered to be the index-species of the upper subzone of the Zigzag Zone.

CALLOVIAN

The Callovian deposits are developed most fully in the Southern slope of the Greater Caucasus (West Abkhazia, Upper Racha, Tskhinvali region). The most interesting section of these deposits is at the v.Tsesi, in the gorge of the left tributary of the Satsiskvilegele. Here above the Bajocian Porphyritic suite unconformably occur:

1. Breccia-conglomerates consisting of material of the Porphyritic suite cemented with crystal calcite and, locally, with graywacke sandstones - 10 m.

2. Greenish-grey coarse-grained graywacke sandstones containing small Gastropoda, bivalvia and floral debris - 5 m.

3. Coarse-grained sandstones with grey limestone intercalations and numerous fragments of charred floral detritus - 8 m.
4. Brown and grey fine-grained sandstones - 6-8 m.
5. Bluish-green and grey aleurolites. In the medium part of the unit carbonate concretion layers appear. Floral remains are common - 35-40 m.
6. Greenish-grey, brown thick-bedded sandstones with ammonite: *Macrocephalites macrocephalus* (Schloth.), *Kepplerites* (*Kepplerites*) *georgicus* Khim.- 30 m.
7. Brown calcareous sandstones and green clays with *Hecticoceras* (*Hecticoceras*) *hecticum* (Pratt.) - 4 m.
8. Alternation of grey shales and clayey sandstones with limestone beds. The unit contains *Macrocephalites macrocephalus* (Schloth.), *M. canizarroi* (Gemm.), *M. cf. rotundus* (Quenst.), *M. madagascariensis* Lem., *Pleurocephalites tumidus* (Rein.), *Kamptokephalites lamellosus* (Sow.), *K. colchicus* (Djan.), *K. subtrapezinus* (Waag.), *Indocephalites chrysoolithicus* (Waag.), *I. caucasicus* (Djan.), *Dolikephalites subcompressus* (Waag.), *Cadoceras* (*Cadoceras*) *elatmae* (Nik.), *C. (C.) modiolare* (d'Orb.), *Sphaeroceras globuliforme* (Gemm.), *Choffatia* (*Grossouvria*) *subtilis* (Neum), *Indosphinctes* (*Indosphinctes*) *pseudopatina* (Par. et Bonar.), *Kepplerites* (*Gowericeras*) *gowerianus* (Sow.), (Djanelidze, 1933; Khimshiashvili, 1957, 1962; Lominadze, 1967).
9. Calcareous and sandy clays passing into clayey sandstones - 90 m.

Units 1-5 only conventionally are attributed to early Callovian. Tsereteli (1968) considers them to be Bathonian.

The first Macrocephalitids appear in layer 6, and layer 8 contains already numerous representatives of early Callovian ammonites that allows to date the host rocks.

As can be seen from the above list of fauna, layer 8 contains representatives of both zones of the Lower Callovian. The majority of Macrocephalitids and *Hecticoceras* (*Hecticoceras*) *hecticum* (Pratt.) are characteristic of the earliest Callovian. (Macrocephalus Zone) while such forms as *Cadoceras* (*Cadoceras*) *elatmae* (Nik.), *C. (C.) modiolare* (d'Orb.), *Choffatia* (*Grossouvria*) *subtilis* (Neum.), *Indosphinctes* (*Indosphinctes*) *pseudopatina* (Par. et Bonar.), *Kepplerites gowerianus* (Sow.), are encountered above this zone.

At the base of layer 9 there have been found *Homeoplanulites* (*Parachoffatia*) *funatus* (Opp.), *Choffatia* (*Choffatia*) *prorsicostata* (Siem.), which are also characteristic of the upper zone of the lower Callovian.

Thus, the lower Callovian of the studied section has quite definitely, above the Macrocephalus Zone, one more biostraton whose index-species can be *Kepplerites gowerianus* (Sow.).

Earlier Khimshiashvili (1962), Tsagareli and Khimshiashvili (1974), Lominadze (1982) pointed out the middle Callovian *Macrocephalites transiens* (Waag.), *Lunuloceras* (*Lunuloceras*) *compressus* (Quenst.) and *Putealicerias* (*Putealicerias*) *metomphalum* (Bonar.).

At the top of layer 9, Khimshiashvili (1962) found Oxfordian bivalvia. The transition from middle Callovian to Oxfordian in the Tsesi section is quite continuous, so the presence of upper Callovian here is beyond any doubt since the bottom of this unit has middle Callovian age and its uppermost beds are attributed to Lower Oxfordian.

Another interesting section is located at the village of Korta:

1. Grey shales with limestone intercalations - 15-20 m.
2. Brown shales interbedded with dense sandstones containing common *Posidonia huchi* (Room.) - 10-15 m.
3. Greenish-grey sandy clays with sandstone intercalations and ammonite fauna: *Macrocephalites macrocephalus* (Schloth.), *Indocephalites caucasicus* (Djan.), *Dolikephalites subcompressus* (Waag.), *Kepplerites* (*Kepplerites*) *rionensis* Khim., *K. (Gowericeras) gowerianum* (Sow.), *Cadoceras modiolare* (d'Orb.), *Pleurocephalites tumidus* (Rein.), *P. pila* (Nik.), *Kamptokephalites lamellosus* (Sow.), *K. subtrapezinus* (Waag.) - 80 m.
4. Yellowish-grey calcareous sandstones with marl intercalations («Korta beds») - 35-40m.

Layers 1-2 because of the lack of Callovian index forms are conventionally attributed to the Callovian. Layer 3, as is seen from the above list, contains index forms of both lower Callovian zones of Western Europe.

Typical middle Callovian forms have been found in the lower horizons of the Korta beds (layer 4): *Putealicerias (Putealicerias) svevum* (Bonar.), *P. (P.) metomphalum acuticosta* (Tsyt.), *P. (Zieteniceras) evolutus* (Lee.). In uppermost levels, *Euaspidoceras ferrugineus* Jeann. and numerous Phylloceratina have been discovered. Djanelidze (1933), Kakhadze (1947) and Khimshiashvili (1957) present an extensive list of late Callovian ammonites from this portion of the section: *Aspidoceras faustum* (Bayle), *Euaspidoceras hirsutum* (Bayle), *Quenstedtoceras lamberti* (Sow.), *Q. henrici* Douv., *Calliphylloceras manfredi* (Opp.), *Putealicerias (Putealicerias) bisulcatum* (Spath.), *Lunuloceras (Lunuloceras) cf. dynastes* Spath. Likewise we found also *Peltoceras athleta* (Phill.). This list of fossil shows that the Korta beds contain forms of both the middle-upper Callovian and the Oxfordian.

Thus, the presence of middle Callovian within the Korta beds may be regarded as proved on the grounds of finds of forms characteristic of this substage - *Putealicerias (Putealicerias) svevum* (Bonar.), *P. (P.) metomphalum acuticosta* (Tsyt) and *P. (Zieteniceras) evolutum* (Lee.).

The both zones of the upper Callovian - Athleta and Lamberti- are also present. The presence in the section of the lower zone of upper Callovian Athleta Zone is substantiated by *Peltoceras athleta* (Phill.), *Euaspidoceras ferrugineus* Jean., *E. hirsutum* (Bayle). The Lamberti Zone has been recognized on the ground of finds of *Quenstedtoceras lamberti* (Sow.), *Q. henrici* Douv., *Putealicerias (Putealicerias) bisulcatum* (Spath.).

From Upper Racha the Jurassic deposits extend towards the southeast, to Tskhinvali region. The best faunistically characterized section is located on the right bank of the Zembiadag river near the village of Kemulta. Here Bajocian volcanics are transgressively overlapped by the suite of Callovian terrigenous rocks represented mainly by grey clayey sandstones whose visible thickness is about 20 m. From this suite Paichadze (1973) recorded the following forms: *Macrocephalites madagascariensis* Lem., *M. canizaroi* (Gemm.), *Kamptokephalites intermedius* (Greif), *Dolikephalites typicus balkarensis* (Ilyin), *Cadoceras (Cadoceras) elatmae* (Nik.), *Kepplerites (Kepplerites) keppleri* (Opp.), *Putealicerias (Putealicerias) cf. punctatum* (Stahl), *Choffatia (Choffatia) radschensis* (Djan.), and also numerous Phylloceratids. Besides numerous Macrocephalitids we have found here *Homeoplanulites (Parachoffatia) funatus* (Opp.) and *Putealicerias (Putealicerias) krakovierne ogivale* (Tsyt.) (Lominadze, 1982).

Analysing this fossils we can see that besides index-forms of the lower Callovian Macrocephalus Zone (representative of the family Macrocephalitidae) we also have here species which usually are encountered above this zone - *Kepplerites (Kepplerites) keppleri* (Opp.), *Cadoceras (Cadoceras) elatmae* (Nik.), and *Homeoplanulites (Parachoffatia) funatus* (Opp.). Consequently, at the base of this suite, as well as in Upper Racha, it is possible to specify two biostratigraphic levels.

The upper horizons of the suite may be dated as middle Callovian by characteristic forms of this substage: *Putealicerias (Putealicerias) cf. punctatum* (Stahl) and *P. (Zeitenicerias) krakoviense ogivale* (Tsyt.). In this section the uppermost Callovian is not exposed.

In the western part of the Gagra-Djava zone (in Abkhazia) the Callovian is represented, as well as in Racha, chiefly by clayey-sandy facies that transgressively overlie older formations.

Within the middle reaches of the river Bzibi the Bajocian-Bathonian sediments are unconformably overlapped by conglomerates, aleurolites, graywacke sandstones, gravelstones, limestone lenses of total thickness 150-200 m. These deposits contain numerous Callovian ammonites: *Dolikephalites subcompressus* (Waag.), *Macrocephalites transiens* (Waag.), *M. madagascariensis* Lem., *M. verus* Buck., *M. canizaroi* (Gemm.), *Indocephalites caucasicus* (Djan.), *I. cf. sp. haericus* (Geif), *Pleurocephalites subtumidus* (Waag.), *P. tumidus* (Rein.), *Bullatimorphites bullatus* (Orb.), *Choffatia (Choffatia) tsessiense* (Djan.), *C. (C.) recuperoi* (Gemm.), *C. (C.) neumayri* (Siem.), *C. (C.) baluchistanensis* (Noetl.), *Flabellisphinctes villanyensis* (Till.), *Homeoplanulites (Parachoffatia) aff. funatus* (Opp.), *Indosphinctes (Indosphinctes) pseudopatina* (Par. et Bonar), *I. (I.) choffati* (Par. et Bonar.), *I. (I.) urbanus* Spath, *I. (I.) luceyensis* Mang., *I. (I.) bretoni* Coll., *Kepplerites (Gowericerias) gowerianus* (Sow.), *Putealicerias (Putealicerias) lugeoni* (Tsyt.), *P. (P.) metomphalum multicostatum* (Tsyt.), *Lunuloceras (Lunuloceras) compressus* (Quenst.), *L. (L.) pavlovi* (Tsyt.), *Jeanneticeras anomalum* Elmi, (Kakhadze, 1947; Khimshiashvili, 1957, 1962; Lominadze,

1982). All the above mentioned forms indicate the presence of both lower Callovian zones whereas such forms as *Macrocephalites transiens* (Waag.), *Putealicerias* (*Putealicerias*) *lugeoni* (Tsynt.) and *P.(P.) metomphalum multicostatum* (Tsynt.) point to the presence of middle Callovian. The uppermost part of this sequence Khimshiashvili (1962) attributes, on the ground of finds of bivalvia, to late Callovian and early Oxfordian (Fig. 2).

CONCLUSIONS

Analysis of fossil ammonite assemblages shows that in Georgia all stages of the Middle Jurassic can be reliably recognized and, besides, the presence of certain zones of these stages have been recognized.

Ammonites from the most ancient early Aalenian Opalinum Zone are known almost in all tectonic units of Georgia. By comparatively rich fossils assemblages this zone is distinguished in the Kachetian part of the Kazbegi-Lagodekhi structural-facial zone. Ammonites from this zone belong to genera *Leioceras*, *Costileioceras* and *Bredya*.

In Kakheti layers containing *Ludwigia obtusififormis buckmani* Gec. correspond to Murchisonae Zone. In the same area Bradfordensis Zone is characterized by finds of *Brasilia sublineata* Buck. and *B. bradfordensis* Buck.

The base of the Bajocian stage - the Discites Zone - is also recognized in Kakheti by the presence of *Hyperlioceras* and *Euhoploceras crassispinatum* Buck.

The Sauzei Zone is established in the Dzirula massif on the ground of *Emileia contracta* (Sow), *E. polyschides* (Waag.), *Skirroceras freycineti* (Baile).

The overlying Humphriesianum Zone has been characterized by the index-species and also by *Normannites braikenridge* (Sow.) found in the Dzirula massif.

The presence of the next, Niortense Zone is confirmed by the single find of *Garantiana baculata* (Quenst.) in the Dzirula massif.

The Garantiana Zone is recognized within the Georgian block. It contains *Garantiana cf. bifurcata* (Ziet.) and *G. garantiana* (d'Orb.).

Frequent finds of the representatives of *Parkinsonia* allow to assert the presence of the Parkinsoni Zone - the uppermost zone of the Bajocian stage.

In Georgia the Bathonian deposits are characterized by ammonites very poorly. For that reason we can speak only about the existence of occasional zones.

FIG. 2.—Correlation of generalized stratigraphic columns of Middle Jurassic of Georgia. 1 - Clayey shales and argillites; 2 - Bedded sandstones; 3 - Sandstones; 4 - Clayey sandstones; 5 - Conglomerates; 6 - Marls; 7 - Limestones; 8 - Volcanogenic rocks; 9 - Tuff-sandstones; 10 - Ammonites.

FIG. 2.—Correlación de los perfiles generales de la sucesión estratigráfica del Jurásico Medio de Georgia. 1: Argilitas y pizarras arcillosas; 2: Areniscas en bancos; 3: Areniscas; 4: Areniscas arcillosas; 5: Conglomerados; 6: margas; 7: Calizas; 8: Rocas volcánicas; 9: Areniscas vulcanosedimentarias (Tuff); 10: Ammonites.

For instance, the early Bathonian, Zigzag Zone, has been recognized in the southern slope of the Greater Caucasus, in the Gagra-Djava zone (Abkhazia) and in the Lesser Caucasus (South Georgia). The presence of middle Bathonian (Bremeri Zone) is proved only in the Tskhinvali region (v. Tsona). As to upper Bathonian its lowermost zone - (Retrocostatum Zone) was recognized in the Tskhinvali region and Racha.

The Callovian deposits are best characterised by ammonite fossils, however the identification of several zones is not possible in all sections.

The Macrocephalus Zone is paleontologically best characterised and can be distinguished almost in all sections in Racha, Abkhazia and Tskhinvali region.

The regional Gowerianus Zone is distinguished also in all the studied section, but paleontologically it is substantiated worse than the former.

Middle Callovian is identified mainly on the ground of finds of the representatives of the Hecticoceratinae subfamily.

New investigations showed that the identification in Georgia of the Anceps Zone which makes the lower middle Callovian zone in Western Europe is not justified; first, representatives of this genus are not encountered in Georgia; second, interrelation between middle Callovian fauna in sections remains unclear. In our opinion, it is better not to subdivide the middle Callovian into zones but to describe it as beds with *Putealicerias metomphalum*.

Most upper Callovian zones are characterised only in Racha. Here, by the presence of *Quenstedtoceras lamberti* (Sow.), *Q. henrici* Douv., *Euaspidoceras ferrugineus* Jeann., *Putealicerias (Putealicerias) bisulcatum* (Spath) both zones of Late Callovian -Athleta and Lamberti - have been recognized.

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