Upper Triassic–Lower Jurassic volcanogenic and sedimentary deposits of the Old Zod Pass (Transcaucasia)

Article *in* Stratigraphy and Geological Correlation · January 1997

Nikita Bragin
Russian Academy of Sciences

Stratigraphy and Geological Correlation, Vol. 5, No. 3, 1997, pp. 257–264. Translated from Stratigrafiya. Geologicheskaya Korrelyatsiya, Vol. 5, No. 3, 1997, pp. 58–65.

Upper Triassic–Lower Jurassic Volcanogenic and Sedimentary Deposits of the Old Zod Pass (Transcaucasia)

A. L. Knipper*, M. A. Satian, and N. Yu. Bragin***

* *Geological Institute, Russian Academy of Sciences, Pyzhevskii per. 7, Moscow, 109017 Russia*
** *Institute of Geology, Academy of Sciences of Armenia, ul. Marshala Bagramyana 24a, Yerevan, 375019 Armenia*
Received March 20, 1995; in final form, June 20, 1995

Abstract—Upper Triassic–Lower Jurassic volcanogenic and sedimentary deposits refered to the upper part of the section of the Ipyak ophiolite nappe (the Sevan–Akera zone, Lesser Caucasus) were studied and described for the first time. The section of these deposits on the Old Zod Pass is found to be represented by sedimentary volcaniclasic breccias with horizons of lavas, sandstones, jaspers and limestone blocks. Jaspers comprise radiolarians of two stratigraphic levels: upper Carnian and Toarcian. These data suggest that the plutonic part of the Sevan–Akera complex is not younger than the late Carnian.

Key words: *Lesser Caucasus, Sevan–Akera zone, ophiolites, volcanic series, breccias, Carnian, Toarcian, radiolarians*

INTRODUCTION

Volcanic successions of the Sevan–Akera zone of the Lesser Caucasus (Fig. 1), which crown the section of ophiolite allochthons (Knipper and Sokolov, 1974), have now been described in detail. Established among them are sequences of different composition, which have formed in different geodynamic settings, and which have complicated time and space relationships (Zakariadze *et al.*, 1986; Zakariadze *et al.*, 1990; Knipper *et al.*, 1985).

Thanks to abundant microfauna, some parts of these deposits are reliably dated at present as the Albian–Cenomanian and Late Jurassic–Neocomian in age (Gasanov, 1985; Zhamoida *et al.*, 1976; Zakariadze *et al.*, 1986; Zakariadze *et al.*, 1990; Knipper *et al.*, 1985; Satian, 1984; Tikhomirova, 1983; Zakariadze *et al.*, 1983). There is also paleontological evidence for the Middle Jurassic age of a certain part of the above succession (Gasanov, 1985). New data allow us to revise the age of the volcanic sequence and to assign its minimum time limit to the Late Triassic.

A.N. Solovkin was the first to reveal the Upper Triassic deposits within the Sevan–Akera ophiolite zone of Armenia and Azerbaijan in 1950 (Shikhailibeili, 1964). He described brown ferruginized medium-grained crystalline limestones with Late Triassic fauna among tuffs and jaspers in the vicinity of Asrik Village (the Akera River upper course). No fauna of this age was found afterwards, which led Shikhailibeili to question the validity of these data and to consider the limestones described by Solovkin as a part of the upper Santonian volcanosedimentary sequence.

In 1982, G.A. Kazaryan found the middle Norian fauna (*Halobia norica* Mojs. identified by I.V. Polubotko) in the Old Zod Pass area in limestone blocks enclosed in the volcanosedimentary sequence which he considered to be of Late Jurassic–Early Cretaceous age. Unfortunately, the data on the Zod section were not published, and the information cited above is based on personal communication of Kazaryan and Polubotko. As these data are of great importance in elucidating the formation history of the ophiolite complex, and of its volcanic series in particular, Knipper and Satian thoroughly studied this section in 1988 (Knipper, 1991). The work has yielded unexpected results due to bivalves found in limestones and microfauna abundant in jaspers and pelites.

STRUCTURE OF THE SECTION

The rock sequence described below (Fig. 2) is exposed in the watershed area along the old pathway ascending from the Zod Mine (Armenia) in the south and descending into the Soyutluchai River valley (Azerbaijan) in the north, where the base of the section is located. This site is known as the Old Zod Pass.

As Fig. 2 shows, the sequence is subdivided into three parts, the lower and upper parts being represented by alternating specific breccias and basic volcanic rocks while the middle part consists of various interbedding sedimentary rocks, basalts and basaltic andesites.

I. The lower part of the section includes two breccia members separated by a lava horizon. At the base, the lower member is composed of compact diabase detritus. The rock fragments are unrounded, unsorted,

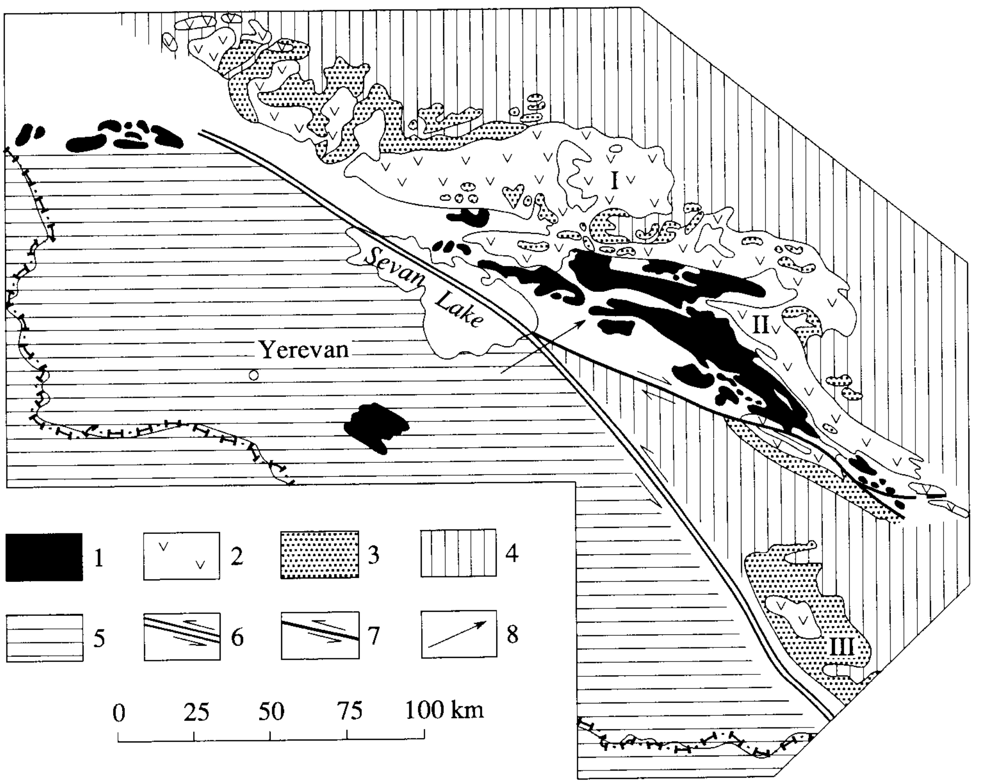

Fig. 1. Location of ophiolite massifs in the Lesser Caucasus structure (modified after Zakariadze *et al.*, 1990).
(1) Ophiolite allochthons: Mesozoic calc–alkaline series of the Somkhet–Agdam (I), Karabakh (II) and Kafan (III) zones. (2) Jurassic. (3) Upper Jurassic–Cretaceous: crystalline basement under the cover of Mesozoic and Cenozoic deposits. (4) Hercynian (the Eurasian type). (5) Precambrian (the Gondwanian type). (6) Late Cretaceous suture. (7) Post-Late Cretaceous strike slip faults. (8) Location of the described section.

acute-angled, and the size varies from millimeters to 30–40 cm along the long axis. The structure of rock fragments and the degree of crystallization indicate their dike origin. This is also confirmed by the presence of fragments in which the primary contact of two dikes with a different degree of crystallization is marked by a quenching zone. The matrix is represented by a fine-clastic (silt–sandstone and gravel) ungraded mass composed of fragments of different gabbros (melanocratic to leucocratic), gabbro–diabases, dolerites, and their minerals. Sometimes these fine-grained rocks compose indistinct lenses and interlayers with a flourlike texture. Upsection, in the middle part and at the top of the member, the composition of the debris changes, and abundant fragments of gabbro are represented by cumulative (leucocratic and melanocratic), foliated, isotropic and pegmatoid varieties, as well as by flaser gabbro. Sometimes, fragments of gabbro are rounded or subangular, and oblate (pebbles). One pebble of quartz porphyry 5 cm in diameter and one well-rounded oblate pebble of marbelized limestone of much the same size were found in lenses and irregular segregations of fine-clastic material composing a matrix between diabase and gabbro fragments. The variable composition and roundness of some breccia fragments and the texture features indicate the sedimentary origin of the breccia. The visible thickness of the member is 120 m.

Breccias are overlain by a 50-m horizon of dark green basalts and basaltic andesites with massive, in places pillow texture, which cement breccia fragments at the base of the member. These vesicular lavas display amygdules filled with calcite. The lavas are well crystallized in general and have a microdiabase structure. Rocks are metamorphosed to the greenschist facies. Sills of aphyric olivine diabases, with olivine replaced by aggregated chlorite and iddingsite, are observed in lavas. The pyroxene–plagioclase matrix of lavas is of typical diabasic structure. Pyroxene is almost completely replaced by actinolite, whereas plagioclase, by prehnite. It should be stressed that no sign of breccia-tion structure can be observed in these magmatic rocks; this differentiates them from breccias of the lower part of the section

Volcanics are again overlain by breccias, which are similar to those described above. This part of the section contains a great amount of the fine-clastic matrix with cross- and graded-bedding clearly indicating its sedimentary origin. Blocks of gabbro may be as great as 1 m in diameter in this part of the section. The thickness of the member is 30 m.

II. The middle part of the section borders the lower part along a small-amplitude fault and consists mainly of sedimentary rocks of various composition alternating with sheets of basalts and basaltic andesites. This part of the section shown in Fig. 2 comprises four rock groups.

1. Basalts and basaltic andesites composing sheets from 5 to 20 m thick. Massive and pillow lava sheets alternate with lava agglomerates and lava breccias.

2. Banded red jaspers as well as gray and pink siliceous shales (pelites) making up thin (1–2 m) interlayers. Only in the lower part of the section is a thick member of pellites (20 m) observed. These rocks often alternate in the middle part of the section with beds of gray micrites and micritic breccias cemented by the jasper matrix. Late Carnian radiolarians were found in the lower member of siliceous shales: *Capnuchosphaera* sp. cf. *C. tricornis* De Wever, *C. lea* De Wever, *C.* sp. cf. *C. triassica* De Wever, *Canoptum* sp., *Capnodoce* sp. cf. *C. antiqua* Blome, *Japonocampe nova* (Yao), *Pentaspongodiscus* sp. cf. *P. dercourti* De Wever, *Spongostylus carnicus* Kozur et Mostler, *S.* sp., and *Xipha pessagnoi* (Nakaseko et Nishimura) (Fig. 2, Plates I, II). This association is similar to the late Carnian radiolarian assemblage from the Isparta Chay Formation (southern Turkey, Antalia nappes) (De Wever *et al.*, 1979). All species cited above occur also in other areas of the Mediterranean–East Asian paleobiogeographic province of the Triassic radiolarian fauna (Bragin, 1994). Many of the mentioned species are found in the upper Carnian deposits of the southern Sikhote–Alin (Bragin, 1991a) and Koryak Range (Bragin, 1991b).

The upper member of siliceous shales (see Fig. 2, Plate II) comprises radiolarians *Acanthocircus* sp., *Bernoullius* sp., *Crubus* sp. cf. *C. wilsonensis* Carter, *Hsuum* sp. cf. *H. minoratum* Sashida, *Hsuum* (?) sp., *Parahsuum* sp., *Paronaella variabilis* Carter, *Parvicingula* (?) *gigantocornis* Kishida et Hisada, and *Trillus* sp. cf. *T. elkhornensis* Pessagno et Blome. The association can be correlated with the Toarcian associations of British Columbia (Carter *et al.*, 1988), Japan (Sashida, 1988), southern Sikhote–Alin (Bragin, 1993), and the basal volcano-silicilyte rocks of Hole 22 in the Koshuni River basin of the Kafan region of Armenia (Vishnevskaya, 1991).

3. Sandstones composing three horizons from 5 to 10 m thick. Each horizon exhibits peculiar features and thus should be described separately.

The lower horizon is composed of gray-green, thin-bedded, fine-grained sandstones with well graded and poorly or partly rounded grains. Thin (1–5 mm) clay laminae, containing small, carbonized plant detritus (<1%) and unidentified radiolarians and foraminifers, closely alternate in the section. Clastics are represented mainly by fragments of partially chloritized serpentinites (80%) and albite (10%). Quartz fragments are absent.

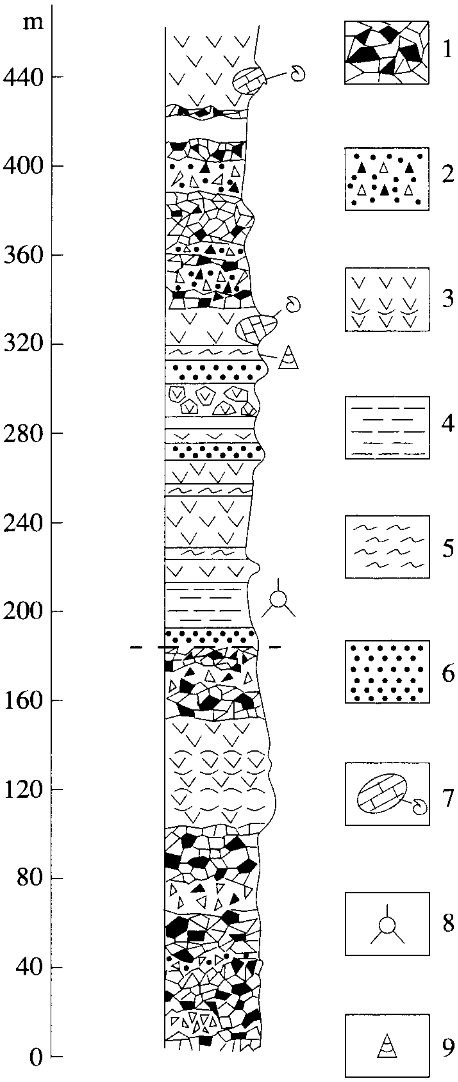

Fig. 2. Section of Upper Triassic–Lower Jurassic Deposits of the Old Zod Pass: (1) Sedimentary breccias predominantly of the gabbro–diabase composition; (2) lenses and bands of coarse-grained sandstone inside breccias; (3) basalts and basaltic andesites; (4) pelites; (5) jaspers; (6) distal turbidites and contourites of the graywacke composition; (7) limestone blocks with Norian bivalves and conodonts; (8) Carnian radiolarians; (9) Toarcian radiolarians.

The middle horizon is composed of silty sandstones with a fine cross-bedding. Grains are well graded and poorly rounded. The clastic fraction consists of quartz, whose content varies from 5 to 20% in individual layers, as well as of albite (5%) and of small fragments of serpentinites (partially chloritized) enclosed in a fine-grained matrix. Accessory minerals are sphene, tourmaline and garnet.

The upper horizon is composed of coarse-, medium-, and fine-grained sandstones of graywacke composition with signs of bioturbation and water currents. These are typical turbidites. Grains are medium-graded and

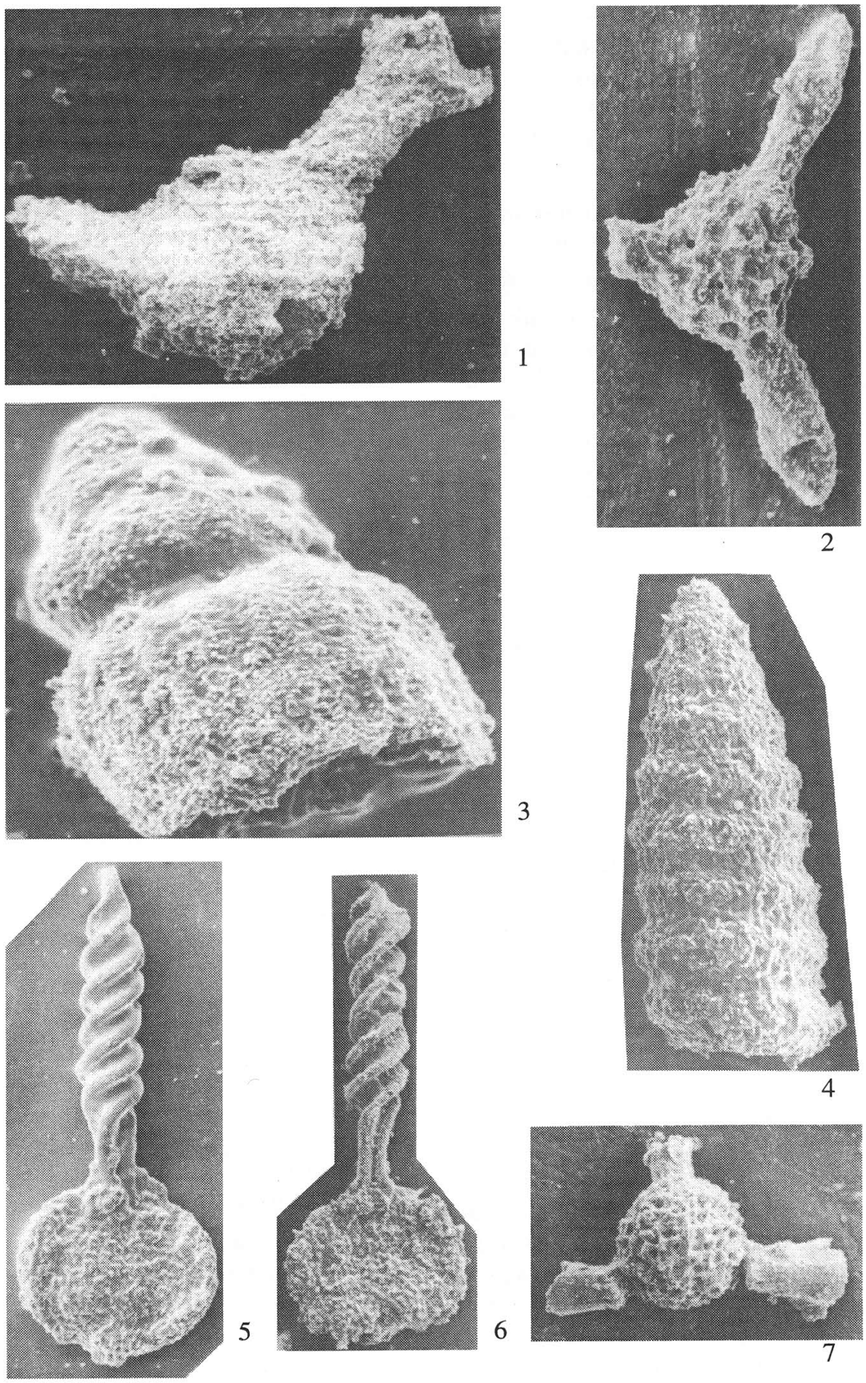

Plate I. Triassic radiolarians (see Fig. 2, symbol 7).
(1) *Capnuchosphaera* sp. cf. *C. tricornis* De Wever, ×250; (2) *Capnodoce* sp. cf. *C. antiqua* Blome, ×325; (3) *Xipha pessagnoi* (Nakaseko et Nishimuta), ×430; (4) *Canoptum* sp., ×325; (5 and 6) *Spongostylus* sp., ×325; (7) *Capnuchosphaera lea* De Wever, ×180.

poorly rounded. The percentage of clastic fraction ranges greatly from layer to layer. Clasts of minerals are represented by quartz (30–40%), albite (0–10%), muscovite and biotite (1–5%), and individual zircon grains. Prevalent among rock fragments (10–60%) are cherts, serpentinites, aphyric basalts, basaltic andesites, limestones, and quartz–mica green schists.

All siliciclastic rocks described above can be regarded as distal turbidites (at least, in the upper member), although, as the graded bedding is not evident in the two lower members, their origin under the influence of contour currents must not be rulled out.

4. The next rock group comprises exotic blocks of middle Norian limestones of 5–10 m^3 in size, well pronounced in relief. These inclusions occur at the base of

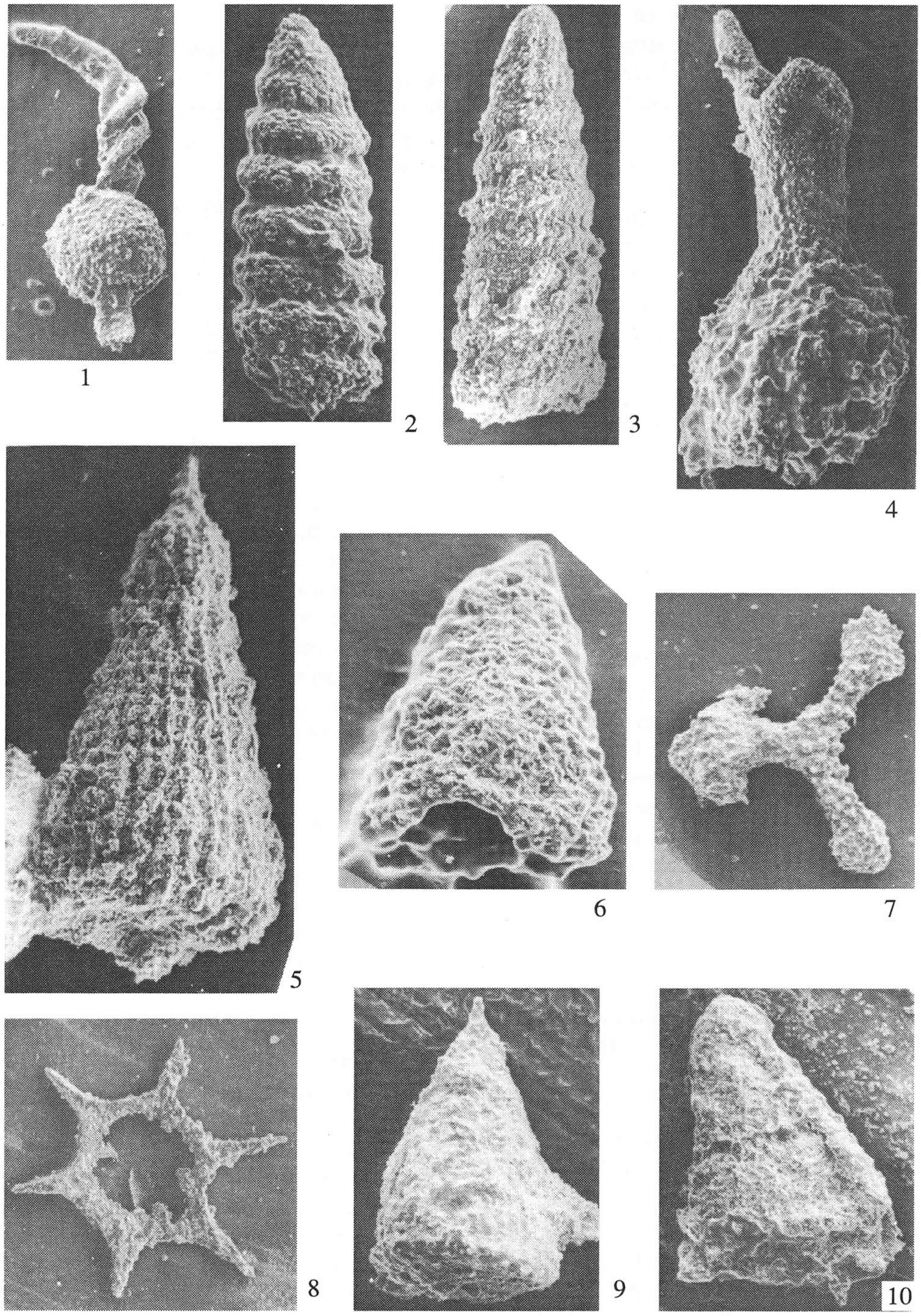

Plate II. Triassic radiolarians (see Fig. 2, symbol 7).

(1) *Spongostylus carnicus* Kozur et Mostler, ×180; (2) *Japonocampe nova* (Yao), ×325; (3) *Canoptum* sp., ×325; (4) *Capnuchosphaera* sp. cf. *C. triassica* De Wever, ×325. Early Jurassic radiolarians (see Fig. 2, Symbol 8). (5) *Hsuum* sp. cf. *H. minoratum* Sashida, ×325; (6) *Crubus* sp. cf. *C. wilsonensis* Carter, ×325; (7) *Paronaella variabilis* Carter, ×250; (8) *Spongosaturnalis* (?) sp., ×325; (9) *Hsuum* (?) sp., ×325; (10) *Parahsuum* sp., ×325.

the lava member, immediately above the radiolarite horizon with the Toarcian fauna (Fig. 2). The blocks are composed of gray, pink, and cherry nodular biomicrites of the "ammonitico rosso" type. The texture of these rocks is very specific. In places, they are well bedded and comprise alternating laminae and beds of different-colored biomicrite from 2 mm to 2–3 cm thick. Beds up to 20–30 cm thick made up of one-color rocks occur more rarely. Usually the bedding is disrupted, and fragments of thin beds of gray and pink biomicrite are broken, embedded in and partially cemented by cherry biomicrite. Limestones often display a conglomeratetype texture. In this case, fragments of gray or light pink biomicrite have rounded edges, are oriented differently with respect to each other, and are cemented by cherry biomicrite. Limestones comprise many stylolite seams along which iron hydroxides accumulate. Thin shells of bivalves and their detritus are abundant in biomicrites. Solitary fragments of crinoid stalks, ostracode shells, and possibly ammonites can be observed. Thin lenses and interbeds (up to 3–4 cm) made up completely of coquina are not uncommon, and bivalve shells here seem to be enclosed in each other and are overturned, which seems to indicate that they were transported by bottom currents.

The rock texture described above is likely to have developed when the carbonate mass, composed of lithified gray and pink micrites and still unlithified cherry micrite ooze, was sliding down the underwater slope. The process was accompanied by a partial dissolution and reworking of lithified limestones. It is worth noting that the surface of Upper Triassic limestone blocks is covered in places with a brown iron–manganese–cherty crust 1–2 mm thick. It is not improbable that this is the remains of a "roasted" crust that originated when limestone blocks slid down to a still hot lava flow.

The insoluble part of limestones is composed of heavy (barite, hypersthene, augite, hornblende, actinolite–tremolite, biotite) and light minerals (volcanic glass, quartz, ocherous particles). Barite is most likely authigenic, whereas the dark-colored minerals were derived by the destruction of basic volcanics.

Limestones comprise abundant bivalves, among which Polubotko identified the middle Norian *Halobia norica* Mojs. and *Halobia* (?) sp. (*H.* sp. ex gr. *H. salinaria* Bronn.). Bragin found the middle-upper Norian conodonts *Neogondolella navicula* (Huckriede) and *Epigondolella postera* (Kozur et Mostler) in cherry micrites.

We emphasize once again that this part of the section bears no traces of brecciation resembling that of the ophiolitoclastic breccias from the lower part of the section.

III. The base of the upper part of the section is made up of breccias similar in structure to those described above, although gabbro and diabase fragments associate here with fragments of amygdaloidal basalts and basaltic andesites. Breccias are overlapped by massive and pillow lavas of basaltic andesite, which enclose at the base two exotic blocks (3–5 m^3) of the middle Norian limestones that do not differ from the above-described exotic blocks of the middle part of the section. The visible thickness of the upper part of the section is 120 m.

The total visible thickness of the section is approximately 450 m, 250 m (55%) of which is due to sedimentary breccias, 152 m (34%) effusives, 23 m (5%) sandstones, and 29 m (6%) siliceous rocks. The middle part of the section was formed during the time interval from the Carnian to Toarcian inclusive (about 60 Ma).

DISCUSSION AND CONCLUSION

The section described above allows conclusions some of which are definite and apparent from the section structure, whereas others require additional regional material to be invoked and thus are still open to debate.

Conclusions of prime importance are as follows:

1. A part of the continuous volcanosedimentary section, the middle part of which was formed in the late Carnian–Toarcian, is exposed along the Old Zod Pass. Exotic blocks of nodular limestones occur in the Toarcian part of the section and certainly represent slided blocks.

2. About a half of the section (55%) is made up of sedimentary breccias, the products of destruction of different gabbros, diabases, and basic volcanites. Besides, graywackes from the middle part of the section contain abundant reworked serpentinitic material. Thus, the plutonic part of the ophiolite association of the Sevan–Akera zone (serpentinites, gabbro, and a part of the dike complex) is not younger than the late Carnian. Respectively, the formation of the volcanic series began no earlier than at this time. Moreover, the presence of fragments of basalts and basaltic andesites in the upper breccias indicate that the process of brecciation and redeposition of the fragments not only preceded formation of these volcanic rocks, but accompanied it as well.

3. Pelagic sediments (radiolarites, pelites) present in the section, as well as their close relationship with underlying and overlying rocks, suggest that the whole section (including breccias) is likely to have formed in deep-water conditions near the carbonate compensation depth (CCD), which is confirmed by the presence of thin interbeds of micrites and micrite breccias within siliceous rocks.

Whereas breccias as well as lava flows formed during a short time interval that can be neglected, the accumulation of jaspers and pelites could probably proceed very slowly. As the total thickness of the pelagic rocks is 29 m and the accumulation period comes to 60 Ma, then the accumulation rate could be 0.5 mm per thousand years. However, our calculations should take into account that we have data only on the late Carnian age for the base of the member and the Toarcian age for its top, and therefore the stratigraphic interval ranging from the Norian to Sinemurian may appear to be ommitted. Proper allowance must especially be made for the fact that if two lower graywacke horizons (see the description of the middle part of the section) are of contourite origin, then the existence of at least two stratigraphic hiatuses caused by the erosion of sediments by bottom currents should be inferred. Consequently, the accumulation rate for siliceous rocks could be higher than that calculated.

These conclusions are quite possible, although the provenance (or provenances) of blocks of the middle Norian nodular limestones and fragments of metamorphic rocks remains (or remain) an enigma.

In the autochthon of the Sevan–Akera zone, which underlies and bounds the ophiolite allochthons (the Karabakh and Somkheto–Agdam zones, see Fig. 1) on the north and northeast, Triassic deposits are not found and their fragments are absent in Lias coal-bearing deposits overlying the metamorphic rocks (Upper Proterozoic?–Lower Paleozoic?) and Upper Paleozoic volcanogenic and sedimentary deposits. Upper Triassic deposits are encountered only within the Armenian block bounding the ophiolite nappes on the south, but in quite different facies. The Upper Triassic is represented here (Dzhermanis area) by terrigenous coal-bearing rocks.

Strangely enough, nodular limestones of the Old Zod Pass show a great resemblance to similar rocks of the external Dinarides and Oman, exemplifying the northern Mesozoic passive margin of the African–Arabian plate. Moreover, these limestones usually compose blocks occuring within Triassic–Jurassic lava and sedimentary sequences. A chain of allochthons with similar sections has recently been traced to extend from Turkey through southern Iran and Oman to Tibet. It is hardly probable that such a resemblance is coincidental.

In terms of the provenance of metamorphic fragments, it seems that uplifts made up of greenschists were situated inside or on the margins of the basin at this time. Their age is not yet established. The provenance could be represented by pre-Mesozoic sialic complexes or assemblages of the "metamorphic centers" originating, as Wernicke's model suggests, in the course of the Triassic rifting with simple shearing (Wernicke, 1985).

By and large this section seems to have formed in the course of rifting inside the continent (in Satian's opinion) or in the continental margin (in Knipper's view), during which the sialic layer was completely removed (due to extension?), and serpentinites, gabbro, and the dike complex appeared on the floor of the basin as a result of the mantle diapir uplift. All these rocks were brecciated and redeposited under deep-water conditions along the edges of steep submarine scarps. Concurrently with brecciation, dikes continued to intrude, and sheets of basalts and basaltic andesites were formed. The process of brecciation was not temporally constant and had two maxima. The first maximum preceded the accumulation of late Carnian radiolarites, while the second followed the accumulation of Toarcian radiolarites. The sedimentation environment was quiet. The accumulation of siliceous sequences was interrupted only by effusive activity that triggered the inflow of clastics by contour currents and turbidity flows. The activation of tectonic movements in the latest Early Jurassic, when upper breccias were formed, was preceded by the formation of turbidites and by the slumping of middle Norian limestones, which most likely indicates a gradual intensification of the tectonic separation of the relief. The Middle Norian nodular limestones probably accumulated in marginal parts of the emerging troughs or in uplifts around it.

The information presented in this work does not allow the problem of the initial spatial position of the Zod section in the Mesozoic basin (basins) with the ocean-type crust to be solved. It is beyond the scope of this article to deal with the problem. It should be pointed out that one of us, Satian, believes that ophiolite assemblages of the Sevan–Akera zone were formed during rifting and did not experience a substantial tectonic transportation, whereas Knipper speculates that the ophiolites originated when the southern passive margin of the Tethys was split and initially occurred at a distance of thousands of kilometers away from their present position. If so, the Zod section may represent a fragment of the destroyed African–Arabian passive margin of the Tethys.

REFERENCES

Bragin, N.Yu., Radiolarians and Lower Mesozoic Sequences of the Eastern USSR, *Tr. Akad. Nauk SSSR Geol. Inst.*, 1991a, no. 469.

Bragin, N.Yu., Carnian Radiolarian Assemblage from Volcanogenic and Siliceous Deposits in the Ekonai Zone of the Koryak Range, *Izv. Akad. Nauk SSSR, Ser. Geol.*, 1991b, no. 6, pp. 79–86.

Bragin, N.Yu., Stratigraphy of the Jurassic to Lower Cretaceous Cherts and Terrigenous Deposits of Primor'e (Gorbusha Strata), *Stratigr. Geol. Korrelyatsiya,* 1993, vol. 1, no. 2, pp. 93–99.

Bragin, N.Yu., Radiolarians as Indicators of Triassic Climate in Northeastern Asia, *Stratigr. Geol. Korrelyatsiya,* 1994, vol. 2, no. 1, pp. 81–85.

Carter, E.S., Cameron, B.E.B., and Smith, P.L., Lower and Middle Jurassic Radiolarian Biostratigraphy and Systematic Paleontology, Queen Charlotte Islands, British Columbia, *Bull. Geol. Surv. Can.*, 1988, vol. 31, no. 386.

De Wever, P., Sanfilippo, A., Riedel, W.R., and Gruber, B., Triassic Radiolaria from Greece, Sicily and Turkey, *Micropaleontol.,* 1979, vol. 25, no. 1, pp. 75–110.

Gasanov, T.A., *Ofiolity Malogo Kavkaza* (Ophiolites of the Lesser Caucasus), Moscow: Nedra, 1985.

Knipper, A.L., Upper Triassic–Early Jurassic Sedimentary Brecchias in the Ophiolitic Suite of the Lesser Caucasus, in *Ophiolite Genesis and Evolution of Oceanic Lithosphere,* Peters, Tj. *et al.*, Eds., Sultanat of Oman, 1991, pp. 705–713.

Knipper, A.L. and Sokolov, S.D., Pre–Upper Senonian Tectonic Nappes of Lesser Caucasus, *Geotektonika,* 1994, no. 6, pp. 74–80.

Knipper, A.L., Zakariadze, G.S., and Lordkipanidze, M.B., Upper Cretaceous Volcanism of the Sevan–Akera Zone of the Lesser Caucasus (a Place in the History and Relation to the Ophiolite Assemblage), *Geocuy Zbornik. Geologica Carpatica,* 1985, vol. 36, no. 6, pp. 651–682.

Sashida, K., Lower Jurassic Multisegmented Nassellaria from the Hsukaichi Area, Western Part of Tokyo Prefecture, Central Japan, *Sci. Rep. Inst. Geosci. Tsukuba, Sec. B.*, 1988, vol. 9, pp. 1–27.

Satian, M.A., *Ofiolitovye progiby Mezotetisa* (Ophiolite Troughs of Mesotethys), Yerevan: Akad. Nauk Arm. SSR, 1984.

Shikhalibeili, E.Sh., *Geologicheskoe stroenie i istoriya tektonicheskogo razvitiya Malogo Kavkaza* (Geological Stucture and Tectonic History of the Lesser Caucasus), Baku: Akad. Nauk Azerb. SSR, 1964, vol. 1.

Tikhomirova, L.B., Late Jurassic–Early Cretaceous Radiolarians of the Carpathians and Lesser Caucasus, and Their Stratigraphic Implications, *Cand. Sci. (Geol.) Dissertation*, Leningrad: All-Russia Research Inst. of Geology, 1983.

Vishnevskaya, V.S., Late Mesozoic Radiolarian Beds of the USSR, *Izv. Akad. Nauk SSSR, Ser. Geol.*, 1991, no. 2, pp. 57–81.

Wernicke, B., Uniform-Sense Normal Simple Shear of the Continental Lithosphere, *Can. J. Earth Sci.*, 1985, vol. 22, pp. 108–125.

Zakariadze, G.S., Knipper, A.L., Sobolev, A.V., *et al.*, The Ophiolite Volcanic Series of the Lesser Caucasus, *Ofioliti*, 1983, vol. 8, no. 3, pp. 439–466.

Zakariadze, G.S., Knipper, A.L., Sobolev, A.V., *et al.*, Characteristic Features of the Structural Position and Composition of Ophiolite Volcanic Series of the Lesser Caucasus, *Okeanicheskii magmatizm* (Oceanic Magmatism), Moscow: Nauka, 1986, pp. 218–241.

Zakariadze, G.S., Knipper, A.L., Bibikova, E.V., *et al.*, History and Age of the Plutonic Part of the Ophiolite Assemblage, North-Eastern Shore of Lake Sevan, *Izv. Akad. Nauk SSSR, Ser. Geol.*, 1990, no. 3, pp. 17–30.

Zhamoida, A.I., Kazintsova, L.I., and Tikhomirova, L.B., Mesozoic Radiolarian Assemblages of the Lesser Caucasus, *Izv. Akad. Nauk SSSR, Ser. Geol.*, 1976, no. 2, pp. 156–160.