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C. R. Palevol 7 (2008) 327–334
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General paleontology

Discovery of Middle Jurassic (Bajocian) Radiolaria from the sedimentary cover of the Vedi ophiolite (Lesser Caucasus, Armenia)

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Received 12 November 2007; accepted after revision 6 May 2008
Available online 20 June 2008

Presented by Jean Dercourt

Abstract

The Vedi ophiolite, situated southeast of Yerevan (Armenia), represents part of the Neotethyan oceanic lithosphere preserved in the Lesser Caucasus. This ophiolite unit constitutes a large tectonic klippe, a result of obduction during the Upper Cretaceous (Coniacian–Santonian). Relatively well-preserved Radiolaria extracted from radiolarites overlying ophiolitic lavas along the Vedi River consist of Middle Jurassic (Bajocian, U.A.Z. 3–4) species, typical of the Tethyan tropical bioprovince. Assemblages are dominated by Nassellaria and characterised by the presence of species *Cyrtocapsa mastoidea*, *Hexasaturnalis hexagonus*, *Laxtorum (?) hichioense, Stichocapsa japonica* and *Striatojaponocapsa plicarum s.l.* This microfauna provides evidence for the oldest age available so far for the sedimentary cover of the Vedi ophiolite. ***To cite this article: T. Danelian et al., C. R. Palevol 7 (2008).***

Résumé

Découverte de Radiolaires du Jurassique moyen (Bajocien) dans la couverture sédimentaire de l'ophiolite de Vedi (Petit Caucase, Arménie). L'ophiolite de Vedi, située au sud-est d'Erevan (Arménie), représente une partie de la lithosphère océanique de la Néotéthys préservée dans le Petit Caucase. Elle constitue une large klippe résultant d'une obduction survenue au Crétacé supérieur (Coniacien–Santonien). Des Radiolaires assez bien préservés, extraits des radiolarites surmontant des laves ophiolitiques le long de la rivière de Vedi, consistent en espèces du Jurassique moyen (Bajocien, U.A.Z. 3–4), typiques de la bioprovince tropicale téthysienne. L'association est dominée par des Nassellaires et elle est caractérisée par les espèces *Cyrtocapsa mastoidea*, *Hexasaturnalis hexagonus*, *Laxtorum (?) hichioense, Stichocapsa japonica* et *Striatojaponocapsa plicarum* s.l. Cette microfaune fournit l'âge le plus ancien actuellement disponible pour la couverture sédimentaire de l'ophiolite de Vedi. ***Pour citer cet article : T. Danelian et al., C. R. Palevol 7 (2008).***

Keywords: Radiolaria; Radiolarites; Lesser Caucasus; Armenia; Vedi ophiolite

Mots clés : Radiolaires ; Radiolarites ; Petit Caucase ; Arménie ; Ophiolite de Védi

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doi:10.1016/j.crpv.2008.05.001

1. Introduction

Several ophiolite units occur in the Lesser Caucasus (Armenia) and correspond to the eastward extension of the Izmir–Ankara–Erzincan ophiolitic suture zone [24]. They are linked to the geodynamic evolution of the Neotethys Ocean [12]. Since the early 1980s, radiolarian biochronology has played a crucial role in unravelling the geodynamic and palaeoenvironmental evolution of Tethyan oceanic realms and continental margins [2,9–11,13–17,29]. More particularly, palaeontological dating of the sedimentary cover of ophiolites defines the time frame for the opening of the various parts of Tethys [10,15]. Dating radiolarites overlying ancient oceanic crust preserved in the Lesser Caucasus is key to understanding the geodynamic evolution of the greater area between Eurasia and the South-Armenian Block (Fig. 1), a microcontinent detached from Gondwana during the Late Palaeozoic–Early Mesozoic time interval [19,20].

It is generally accepted that there are two main ophiolite zones in the Lesser Caucasus (Fig. 2):

- the Sevan–Akera zone [1,3,19,22,25], situated in the East and Southeast of Lake Sevan, includes also the Amassia–Stepanavan ophiolites that occur in the northwestern part of the country;

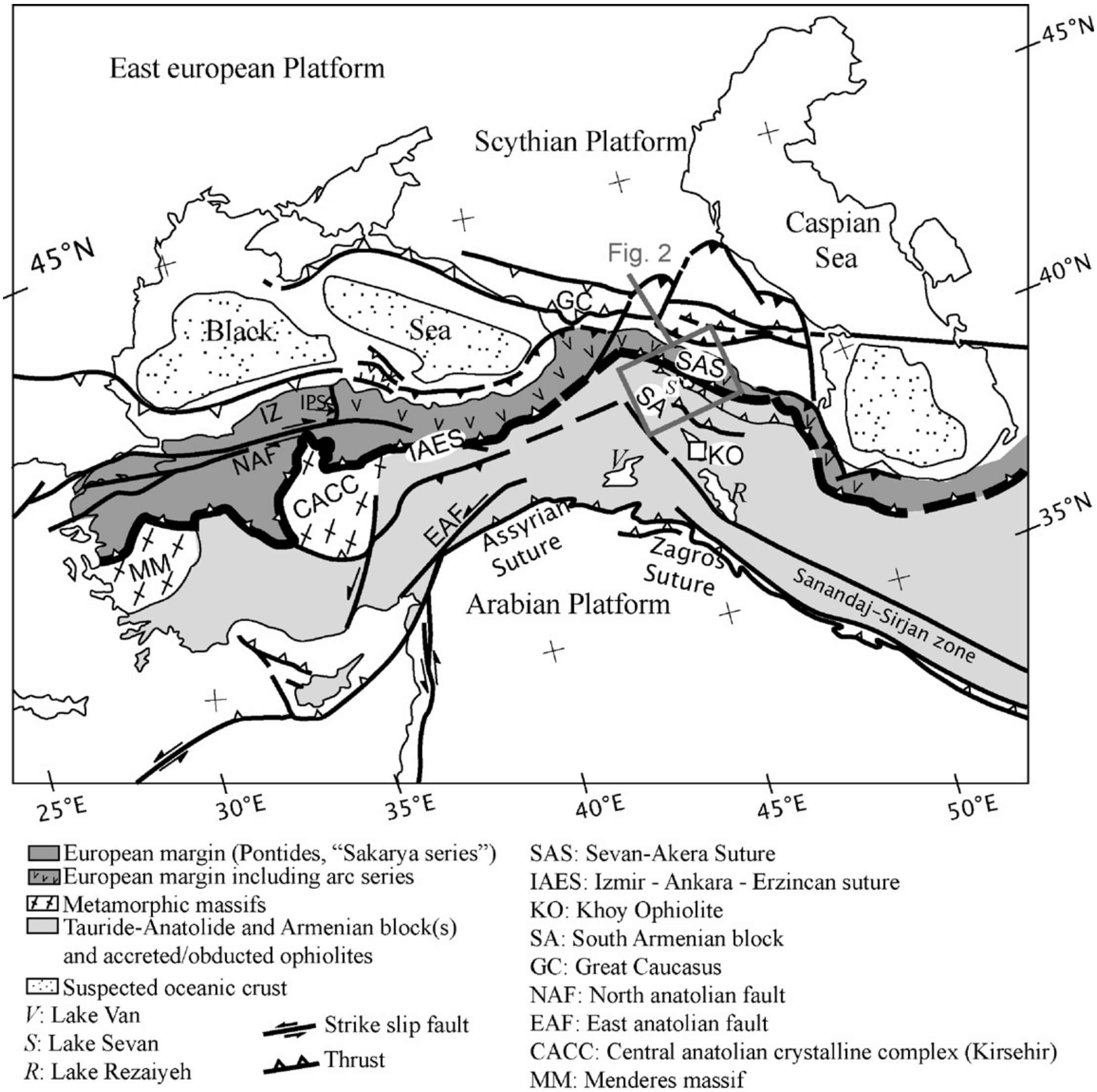

Fig. 1. Structural map of the collisional zone between Arabia and Eurasia (modified after [4]).
Fig. 1. Carte structurale de la zone de collision entre l'Arabie et l'Eurasie (modifiée d'après [4]).

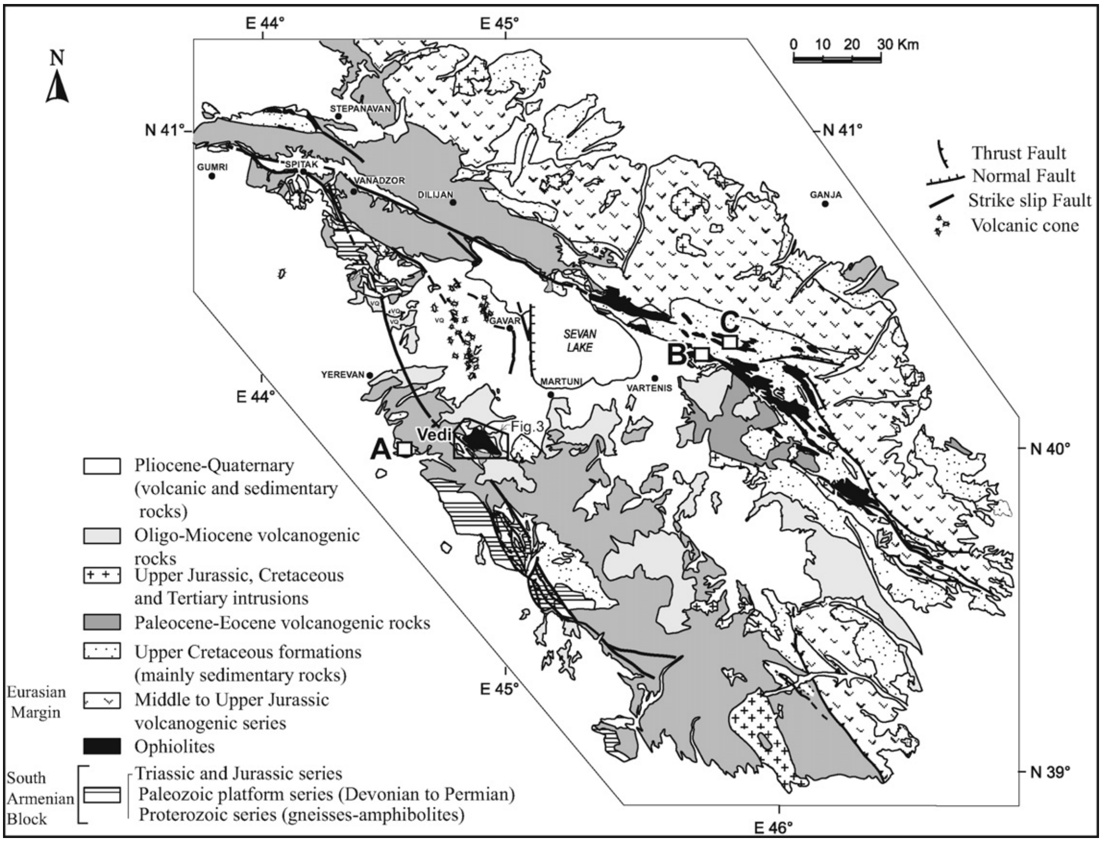

Fig. 2. Geological map of Armenia, including distribution of ophiolitic complexes. Locality A: Erakh mountain, locality B: Zod pass, locality C: Mt. Karawul.

Fig. 2. Carte géologique de l'Arménie, indiquant l'extension des affleurements des complexes ophiolitiques. Localité A : montagne d'Erakh, localité B : passée de Zod, localité C : Mt. Karawul.

- the Vedi ophiolitic unit [3,20,25], cropping out southeast of the capital, Yerevan.

We report here on the discovery of Middle Jurassic (Bajocian) radiolaria yielded from radiolarites overlying lava flows of the Vedi ophiolite and discuss their implications for the Neotethys Ocean preserved in the Lesser Caucasus.

2. Geological setting

The ophiolitic sequence of Vedi is composed of serpentinites, gabbros and a thick pile of massive and pillow lava flows and their sedimentary cover. The latter consists mainly of reddish–brownish radiolarites; however, pelagic limestones with rare ammonites are also present in some areas [7]. Lavas consist of alkaline and tholeiitic basalts and subordinate trachyandesites [30]. The ophiolitic rocks are weakly deformed, including some sheared zones formed in greenschist-facies metamorphic conditions. They occur within a folded klippe sequence that is thrust over a Coniacian sedimentary melange that reworked the ophiolites and was deposited above the Cenomanian–Turonian shallow-water carbonates and the flysch of the South Armenian Block [25] (Fig. 3).

The pillow lavas of the ophiolitic sequence are covered in places by reefal limestones. However, in some areas, they are covered with a conglomerate containing clasts of ophiolitic rocks (gabbros, serpentinites, and basalts). This conglomerate evolves laterally to the reefal limestones, which are built essentially of Late Coniacian *Hippurites*. This sedimentary sequence lies unconformably over the ophiolitic rocks, the melange and the Cenomanian–Turonian shallow-water carbonates of the South Armenian Block. Based on this evidence, obduction is considered to have taken place during the Coniacian–Santonian [21].

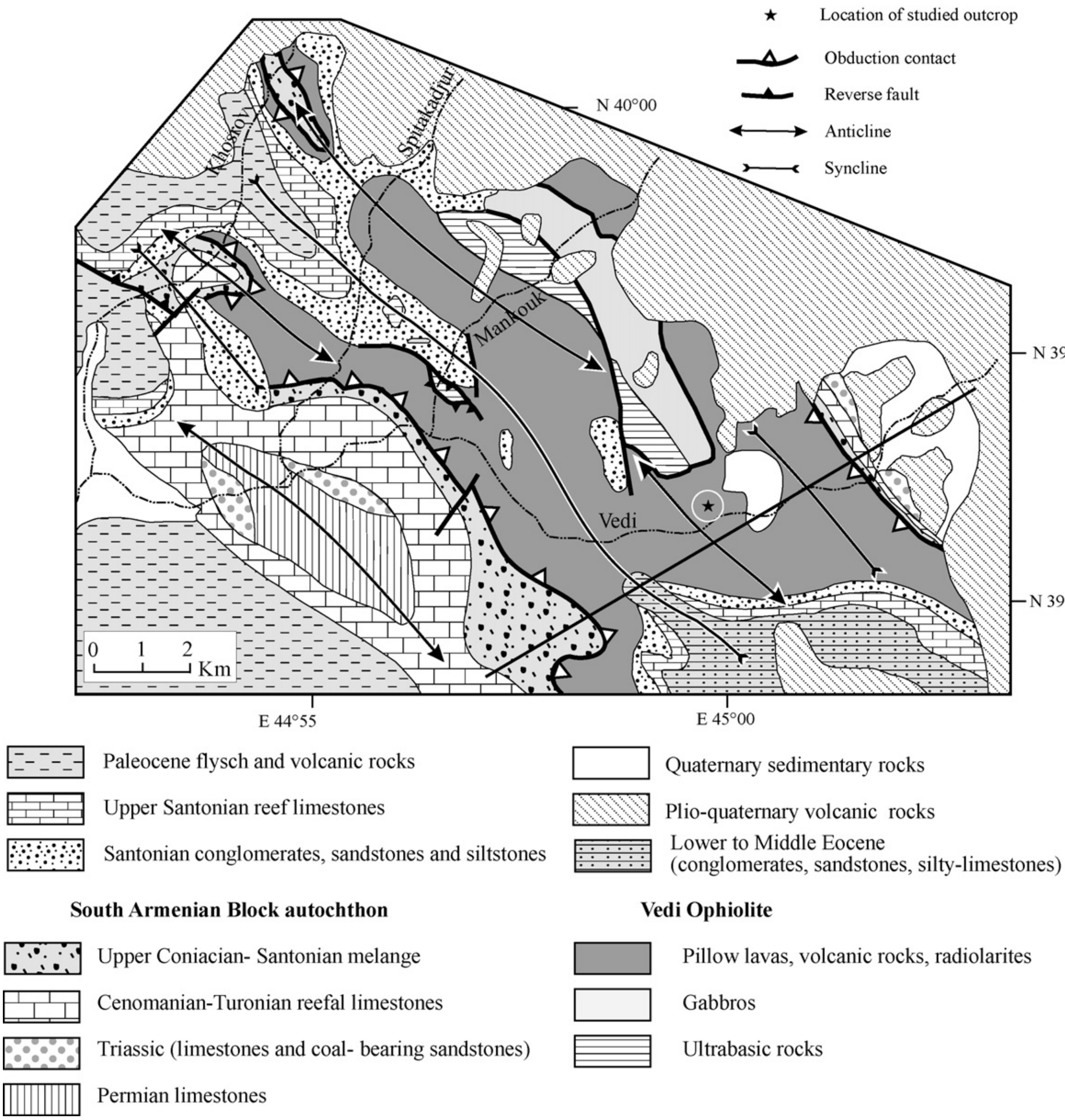

Fig. 3. Geological map of the Vedi area (after [26]).
Fig. 3. Carte géologique de la région de Vedi (d'après [26]).

3. Description of the studied section

The studied section is situated at the southern part of the Vedi ophiolitic unit (Fig. 3), along the road running parallel to the Vedi River (39°56.767′N, 45°0.628′E), where three intervals of red–brownish carbonate-free radiolarites (decimetric chert beds and thin shaly interlayers) are intercalated between volcanic rocks (Fig. 4). These siliceous sedimentary intervals are from west to east approximately 4, 2, and 3 m thick. Lavas situated at the western side of the section display pillow structures that end a thick pile

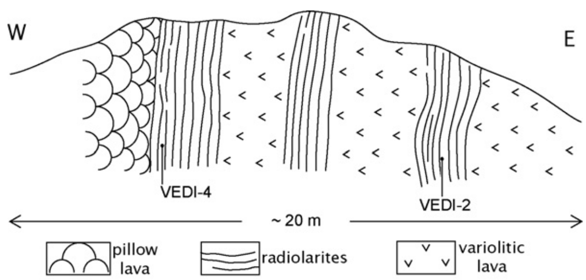

Fig. 4. Simplified drawing of the studied section.
Fig. 4. Croquis simplifié de la coupe étudiée.

of basaltic lava flows observable along the road. Thin section observations of a sample taken from the top of these lavas display some greatly altered (chloritized and barely recognisable) crystals of plagioclase and numerous well-preserved crystals of clinopyroxenes and magnetite in a devitrified-chloritized background. There are also thin hydrothermal veins composed of calcite, chlorite and quartz. Structural and petro-geochemical observations in the larger area of the Vedi ophiolite indicate that these basaltic lava flows are most likely of MORB type. The volcanic rocks, intercalated between and overlying the radiolarites situated at the eastern part of the outcrop, consist of lava with a variolitic texture. Thin-section observations reveal that they are essentially composed of numerous fans of diverging plagioclase needles.

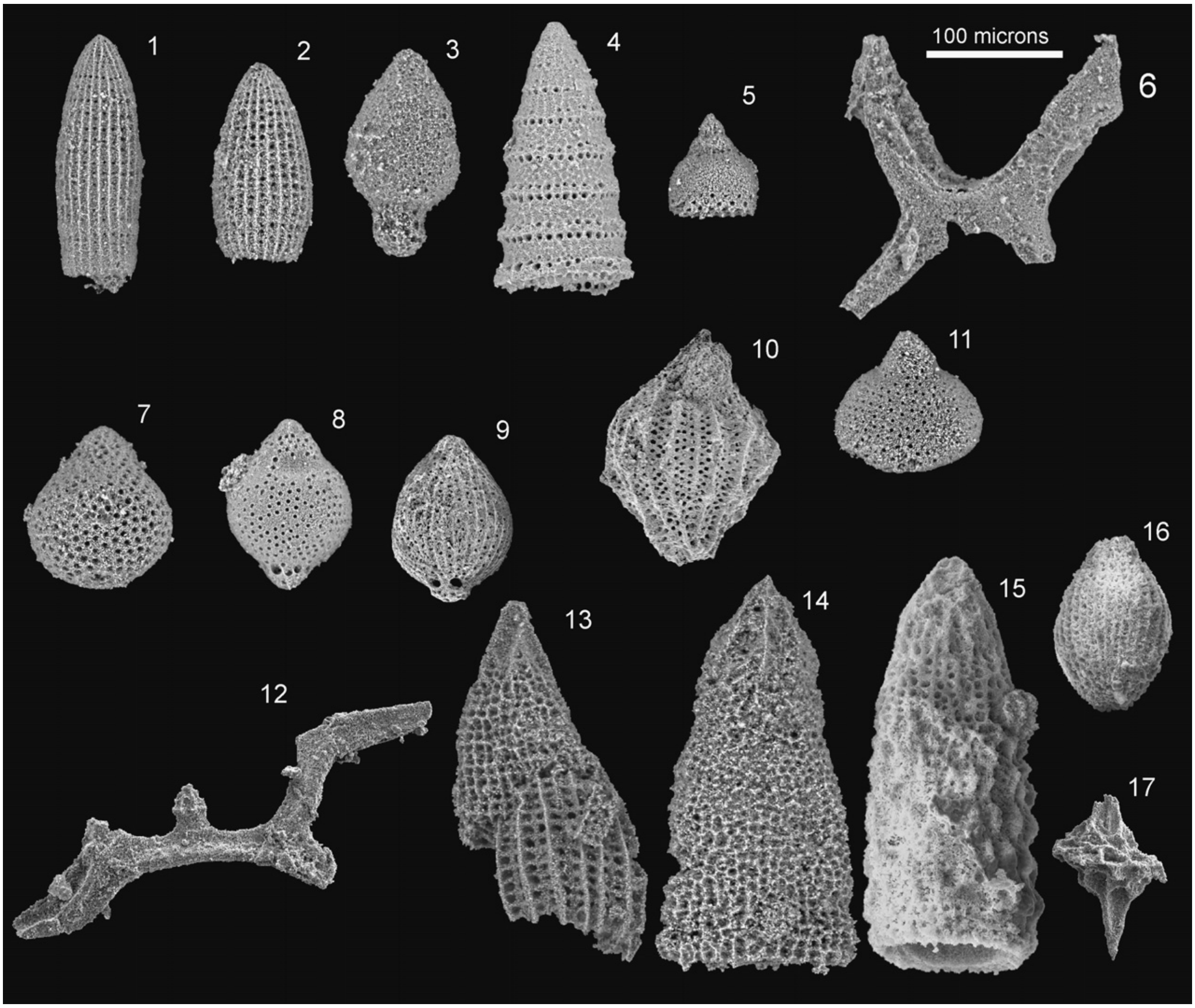

Plate 1. Scanning electron microphotographs of Middle Jurassic Radiolaria yielded from samples Vedi-4 (Figs. 1–11) and Vedi-2 (Figs. 12–17). (**1**) *Archaeodictyomitra prisca* Kozur & Mostler, (**2**) *Archaeodictyomitra rigida* Pessagno, (**3**) *Cyrtocapsa mastoidea* Yao, (**4**) *Dictyomitrella (?) kamoensis* Mizutani & Kido, (**5**) *Eucyrtidiellum unumaense* (Yao), (**6**) *Hexasaturnalis suboblongus* (Yao), (**7**) *Stichocapsa convexa* Yao, (**8**) *Tricolocapsa (?) fusiformis* Yao, (**9**) *Striatojaponocapsa plicarum plicarum* (Yao), (**10**) *Unuma echinatus* Ichikawa & Yao, (**11**) *Williriedellum madstonense* (Pessagno, Blome and Hull), (**12**) *Hexasaturnalis hexagonus* (Yao), (**13**) *Hsuum matsuokai* Isozaki & Matsuda, (**14**) *Laxtorum (?) hichioense* Isozaki & Matsuda, (**15**) *Transhsuum hisuikyoense* (Isozaki & Matsuda), (**16**) *Striatojaponocapsa plicarum* (Yao) s.l., (**17**) *? Zartus imlayi* Pessagno & Blome gr.

Planche 1. Radiolaires du Jurassique moyen, extraits des échantillons Vedi-4 (Figs. 1–11) et Vedi-2 (Fig. 12–17). Photos prises au microscope électronique à balayage.

4. Results

Seven radiolarian chert samples were collected from the section. Two yielded identifiable radiolaria, which were extracted by repetitive leaching of samples with low-concentration hydrofluoric acid (HF 4%). The material was dry picked and mounted on SEM stubs. Taxonomic concepts applied during this study follow those stated by Baumgartner et al. [5] and O'Dogherty et al. [23]. The fauna is typical of the Tethyan tropical bioprovince and is dominated by Nassellaria. The age of the assemblages is discussed in terms of the Unitary Association Zones (U.A.Z.) defined by Baumgartner et al. [6]. Age-diagnostic radiolarian species are illustrated in Plate 1.

Sample Vedi-4 was collected from the *ca*. 4-m-thick radiolarites situated at the western part of the section (Fig. 4). The sample yielded a relatively well-preserved Radiolarian assemblage, dominated by Nassellaria. The following species were identified: *Archaeodictyomitra prisca* Kozur & Mostler, *Archaeodictyomitra rigida* Pessagno, *Cyrtocapsa mastoidea* Yao, *Dictyomitrella (?) kamoensis* Mizutani & Kido, *Eucyrtidiellum unumaense* (Yao), *Hexasaturnalis suboblongus* (Yao), *Saitoum* sp. cf. *S.levium* De Wever, *Stichocapsa convexa* Yao, *Transhsuum* sp., *Tricolocapsa (?) fusiformis* Yao, *Striatojaponocapsa plicarum plicarum* (Yao), *Unuma echinatus* Ichikawa & Yao, *Williriedellum madstonense* (Pessagno, Blome and Hull), *Williriedellum* sp. cf. *W. buekkense* (Kozur) and *Williriedellum yaoi* (Kozur). According to the biozonation of Baumgartner et al. ([6]), *C. mastoidea* last occurs in the Late Bajocian zone 4 (U.A.Z. 4), in which subspecies *S. p. plicarum* first occurs. However, species *S. plicarum s.l.* is found from the Early-mid Bajocian (U.A.Z. 3) onwards. Because the morphotype recorded as present in U.A.Z. 3 is likely to be *S. p. plicarum* (or close to it), we correlate sample Vedi-4 with a slightly wider age range (Early to Late Bajocian, U.A.Z. 3–4).

Sample Vedi-2 was collected from the *ca.* 3 m-thick radiolaritic interval situated in the eastern part of the outcrop (Fig. 4). The sample yielded a reasonably well-preserved Radiolarian assemblage, including the following taxa: *Hexasaturnalis hexagonus* (Yao), *Eucyrtidiellum* sp., *Hsuum matsuokai* Isozaki & Matsuda, *Laxtorum (?) hichioense* Isozaki & Matsuda, *Parahsuum* sp., *Stichocapsa japonica* Yao, *Transhsuum hisuikyoense* (Isozaki & Matsuda), *Striatojaponocapsa plicarum* (Yao) s.l. and *? Zartus imlayi* Pessagno & Blome gr. The co-occurrence of species *H. hexagonus*, *L. (?) hichioense, S. japonica* and *S. plicarum s.l.* characterizes U.A.Z. 3–4 (Early to Late Bajocian) in [6].

5. Discussion and conclusions

Palaeontological data provided for the sedimentary cover of ophiolites are of key importance to understanding the palaeogeographic evolution of the Neotethys in the Lesser Caucasus [4,26].

Previous biostratigraphic data for the sedimentary cover of the Vedi ophiolite were published by Belov et al. [7]. These authors report on the presence of Tithonian–Berriasian and rare Callovian–Oxfordian ammonites in pelagic limestones cropping out in the West of the Vedi ophiolite (i.e. the Erakh Mountain, locality A in Fig. 2). The authors also report on radiolaria yielded from bedded cherts, which are indicative of the Kimmeridgian–Middle Tithonian, the Late Callovian–Kimmeridgian and the Berriasian–Valanginian age ranges, discovered mainly in outcrops situated along the rivers Mankouk and Khosrov. Therefore, the Middle Jurassic (Bajocian) radiolarian assemblages discovered in the section of the Vedi River represent the oldest evidence for the sedimentary cover of the Vedi ophiolite. The oceanic crust in this part of the Neotethys was formed during or most likely before the Bajocian.

It is worth recalling briefly the available biochronologic data from the sedimentary cover of ophiolites preserved in the Sevan–Akera suture zone (Fig. 1). Early studies published in the 1980s [30] reported several Lower Cretaceous (and Upper Jurassic?) levels of red radiolarian cherts associated with ophiolitic lava flows. However, more recently, Late Triassic (Carnian) and Early Jurassic (Toarcian) radiolaria were extracted from siliceous rocks intercalated with ophiolitic breccias in the Zod (Sotk) pass area [22], south-east of Lake Sevan (Locality B in Fig. 2). Further to the east, at Mt. Karawul, Middle Jurassic (Late Bajocian) radiolaria were yielded from radiolarites overlying andesitic and basaltic lava flows [28] (locality C in Fig. 2).

The Armenian ophiolites represent an eastern extension of the Izmir–Ankara–Erzincan ophiolitic suture zone (Fig. 1), in which the presence of Jurassic, but also Upper Triassic and Lower Cretaceous radiolarites intercalated with ophiolitic lava flows are documented [8,27]. It is also possible that they are related to the Khoy ophiolite (Fig. 1), preserved in northern Iran, where there are two distinct oceanic complexes (one pre-Jurassic and one Upper Cretaceous) [18].

In conclusion, our results on the Vedi ophiolite are consistent with the development of a Mesozoic oceanic realm (Neotethys) between the active Eurasian margin to the north and the South-Armenian microcontinent to the south, for which spreading started in the Late Triassic and carried on through most of the Jurassic into the Early

Cretaceous. Part of this oceanic crust, formed possibly during the early Middle Jurassic (Bajocian or earlier), is now visible in the Vedi area, following Late Cretaceous obduction (Coniacian–Santonian).

Acknowledgments

Funding from the Middle East Basins Evolution (MEBE) program, the French Ministry of Foreign Affairs (ECO-NET grant to T. Danelian) and the French Embassy in Yerevan (student grants to G. Asatryan and G. Galoyan) are gratefully acknowledged. Fieldwork was greatly facilitated by the support of the Institute of Geological Sciences (Armenian Academy of Sciences). Constructive remarks by two anonymous reviewers improved the initial manuscript. C. Abrial and A. Lethiers helped with drafting.

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