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19

20 *Abstract*

21 While the Neogene history of the Eastern Mediterranean region is now fairly well understood,
22 our knowledge of older regional paleogeographies is less accurate, especially the positions of
23 blocks and nappes constituting the Aegean Islands prior to the Cenozoic. Our study focuses
24 on the ophiolite exposed on the island of Karpathos (Dodecanese), which is located in the
25 Aegean fore-arc at a pivotal position between the ‘western’ and ‘eastern’ ophiolites of the
26 Mediterranean region and where conflicting Late Jurassic and Late Cretaceous ages have led
27 to diverging tectonic and paleogeographic interpretations. To test these ages, we targeted the
28 radiolarian cherts that depositionally overlie the ophiolite and extracted diagnostic radiolarian
29 assemblages of Aptian (~125–113 Ma), early-middle Albian (~113–105 Ma), and Turonian
30 (~93.9–89.8 Ma) ages. These results suggest that previous Late Cretaceous K-Ar isotopic
31 ages (from 95.3 ± 4.2 Ma to 81.2 ± 1.6 Ma) may have been reset by Late Cretaceous
32 metamorphism or affected by argon loss. Overall, the new Early Cretaceous ages show that
33 the Karpathos ophiolite should not be correlated with the Pindos Nappes of Greece or the
34 ophiolites of Cyprus or Syria but rather with the Lycian Nappes of Turkey and their root
35 located in the Izmir–Ankara–Erzincan Suture Zone. Therefore, the Karpathos ophiolite
36 represents a remnant of the Northern Neotethys, not the Pindos Ocean or the proto-Eastern
37 Mediterranean Basin.

38

39

40 *Keywords:* ophiolite, radiolarite, Radiolaria, Cretaceous, Karpathos, Aegean fore-arc,
41 Neotethys.

42

43 **1. Introduction**

44

45 Present-day convergent margins are often characterized by the occurrence of ophiolites along
46 the upper plate(s) in a large variety of settings related to terrane accretion processes (see Dilek
47 & Furnes, 2014, and references therein). This study focuses on the island of Karpathos
48 (Dodecanese, Greece), which belongs to the Aegean fore-arc (Figure 1) and is located at the
49 junction between two important ophiolite domains of the Mediterranean region: the western
50 region (Dinarides, Hellenides) and the eastern region (Taurides, Cyprus, Syria) (Robertson,
51 2002). Although the Neogene history of the Eastern Mediterranean region is fairly well
52 understood following a very large number of studies and the application of powerful tools
53 such as high-resolution seismic tomography (Royden & Faccenna, 2018, and references
54 therein), our knowledge of older regional paleogeographies is less accurate. In the Aegean
55 Sea, the origin of scattered blocks and nappes constituting the Cyclades, Crete and the
56 Dodecanese is not well understood. In particular, there are some difficulties in establishing
57 precise geological correlations between these islands and the surrounding continental margins
58 (Roche *et al.* 2018).

59 Due to its “pivotal” position between the ophiolite regions of Greece and Turkey, Karpathos
60 has attracted significant geological attention for more than a century (see Appendix
61 “Pioneering studies on Karpathos”, online Supplementary Material at
62 <http://journals.cambridge.org/geo>), but diverging interpretations about the age of the ophiolite
63 have led to conflicting views: while K-Ar geochronology documented Late Cretaceous
64 isotopic ages (Koepke, Kreuzer & Seidel, 1985; Hatzipanagiotou, 1991; Koepke, Seidel &
65 Kreuzer, 2002), the sedimentary rocks overlying the ophiolite were considered to be early
66 Early Cretaceous based on calpionellids, suggesting that the ophiolite could be as old as Late
67 Jurassic (Davidson-Monett, 1974; Aubouin, Bonneau & Davidson, 1976). These two distinct
68 ages led to very different paleogeographic scenarios: the Karpathos ophiolite has been

69 interpreted as a remnant of the Pindos Ocean (Aubouin, Bonneau & Davidson, 1976), the
70 Northern Neotethys (Robertson, 2002), or the Southern Neotethys due to age and petrological
71 affinities with Late Cretaceous ophiolites of Turkey, Syria and Oman (Koepke, Seidel &
72 Kreuzer, 2002).

73 Since no modern radiolarian study has ever been undertaken on the island, we have revisited
74 Karpathos and reassessed the potential of its supra-ophiolitic sedimentary strata, with three
75 major objectives: 1) to solve this chronological conundrum by focusing on radiolarian cherts,
76 2) to improve the correlations between Karpathos and the surrounding Mediterranean
77 ophiolites (Greece, Crete, Rhodes, Turkey), and 3) to develop a better understanding of
78 Neotethys paleogeography and tectonics in the Aegean region.

79

80 **2. Geological setting**

81

82 **2.a. The Xindothio Unit**

83 The Karpathos ophiolite forms relatively small exposures (Figure 2a–c) of mainly
84 serpentinized peridotite with minor occurrences of gabbro and dolerite dykes ('dismembered'
85 type after Coleman, 1977). Early geological studies provided some preliminary descriptions
86 of the magmatic rocks and associated sedimentary strata (de Stefani, Forsyth Major & Barbey,
87 1895; Martelli, 1916; Christodoulou 1960; Aubouin & Dercourt, 1970; online Supplementary
88 Material at <http://journals.cambridge.org/geo>). Later, geological mapping demonstrated that
89 these rocks lie within tectonic slices at the top of the nappe pile exposed in the central part of
90 the island and belong to a tectono-stratigraphic succession described as the 'Xindothio Unit'
91 (Davidson-Monett, 1974; Aubouin, Bonneau & Davidson, 1976; Hatzipanagiotou, 1987). The
92 Xindothio Unit overlies the Kalilimni Unit, a Jurassic to Eocene parautochthonous carbonate
93 platform (Figure 2a), and comprises eight subunits from base to top (Figure 3a): ammonite-
94 bearing marl, belemnites-bearing sandstone, platy limestone with filaments (*Halobia*), grey

95 platy limestone, mafic and ultramafic rocks (serpentinite, gabbro, dolerite), red radiolarite and
96 pink microcrystalline limestone, platy green limestone, fine-grained limestone and siliceous
97 beds. The base of the Xindothio Unit has been dated as early Late Triassic (Carnian) with
98 ammonites (*Tropites subbullatus*; Aubouin, Bonneau & Davidson, 1976), while the top is
99 Campanian–Maastrichtian based on planktonic foraminifera (*Globotruncana stuarti*, *G.*
100 *stuartiformis*, and *G. contusa*; Aubouin, Bonneau & Davidson, 1976).

101 Mafic and ultramafic rocks are commonly found in tectonic contact with the underlying units,
102 whereas the radiolarites depositionally overlie the ophiolite at many locations in the Lastos
103 and Menetes areas (Davidson-Monett, 1974; Aubouin, Bonneau & Davidson, 1976;
104 Hatzipanagiotou, 1987, 1988) (Figures 2a–c, 3a). The depositional nature of this contact is
105 supported by good lateral continuity of the radiolarites which show no significant
106 deformation. The rarity of basalts and the direct contact between the magmatic rocks and the
107 radiolarites suggest that the Karpathos ophiolite formed by relatively slow spreading. Near the
108 contact, red chert beds are 5-15 cm thick, whereas these beds are less abundant upsection and
109 crop out as thin continuous layers or chert nodules. Overall, the radiolarite-pink limestone
110 subunit is approximately 40 m thick (Figures 3a, 4).

111

112 **2.b. Previous ages of the ophiolite and overlying strata**

113 Vinassa de Regny (1901) provided the first study of Karpathos radiolarians, which he
114 observed within ‘phtanites’ (black cherts) and ‘argillaceous jaspers’ (red-maroon cherts)
115 collected in the Lastos area (Figure 2a, b). This pioneering work led to the description of fifty-
116 eight radiolarian morphotypes (online Supplementary Material at
117 <http://journals.cambridge.org/geo>), although most of the identified genera are now classified
118 as *nomen dubium* (O’Dogherty *et al.* 2009). In the light of current radiolarian taxonomy, some
119 of the forms illustrated by Vinassa de Regny (1901) resemble the modern genera
120 *Archaeospongoprunum*, *Hiscocapsa*, *Paronaella*, *Pseudoeucyrtis*, *Pseudodictyomitra*, and

121 *Triactoma*, but their occurrence is difficult to confirm given the discrepancies between 1900s
122 drawings and present-day taxonomy based on three-dimensional scanning electron
123 microscope (SEM) observations. Vinassa de Regny (1901) suggested that the faunal
124 assemblage was possibly Late Cretaceous, although this age determination was tentative due
125 to the absence of radiolarian biozonation at the time. Later, an age determination was obtained
126 on the radiolarite-pink limestone subunit with one calpionellid assemblage (Davidson-Monett,
127 1974; Aubouin, Bonneau & Davidson, 1976) and was assigned to the middle–late Berriasian
128 (145–139.8 Ma; Cohen *et al.* 2013, updated 2018). Consequently, these authors suggested
129 that the ophiolite could be as old as Late Jurassic.

130

131 The K-Ar isotopic ages obtained later on the magmatic rocks (hornblende grains extracted
132 from intrusive dolerites) are much younger than the overlying sedimentary strata (Table 1;
133 Koepke, Kreuzer & Seidel, 1985; Hatzipanagiotou, 1991; Koepke, Seidel & Kreuzer, 2002).
134 In Lastos, two ages range between 84.7 and 79.6 Ma, encompassing the middle
135 Santonian–middle Campanian interval (Cohen *et al.* 2013, updated 2018). In Menetes, the
136 isotopic ages range between 99.5 and 88.4 Ma, corresponding to the middle
137 Cenomanian–middle Coniacian interval.

138

139

140 **3. Studied sections and methods**

141

142 Our study focused on identifying the contact between mafic/ultramafic rocks and the
143 overlying radiolarian cherts in order to select a few localities for sampling. This contact is
144 exposed in the high valley of Lastos on the eastern flank of Mount Kalilimni (Figures 2b, 5)
145 and near the village of Menetes on the southern flank of Mount Homali (Figure 2c). To
146 maximize the quality of the faunas, we selected a variety of radiolarian samples in accordance

147 with specific field techniques previously applied to suture zones and fore-arc belts (Cordey &
148 Krauss, 1990; Cordey & Cornée, 2009). Radiolarians were then extracted by repetitive
149 leaching of samples with low-concentration hydrofluoric acid (HF) and then hand-picked and
150 mounted on aluminium stubs for SEM observation and taxonomical identifications (Tabletop
151 SEM Phenom ProX, University of Lyon).

152

153 In Lastos, our samples were collected from two sections:

154 1/ section 'North Lastos road' (Figure 2b; Table 2). This section is composed of an outcrop of
155 serpentinites depositionally overlain by radiolarian cherts and pink limestones. KAL01 was
156 collected from a red radiolarite bed situated 30 cm above the serpentinite body (Figure 3b).

157 Similar stratigraphic contacts between serpentinites and radiolarites are visible at several
158 locations along the North Lastos road (Figures 2b, 5b, c).

159 2/ section 'Hill 730 m' (Figure 2b, Table 2). This section was previously described by
160 Davidson-Monett (1974) and Aubouin, Bonneau & Davidson (1976) under the name 'section
161 of hill 738 m' (Figures 3b, 4) and renamed to follow the revised topography available on the
162 Karpathos-Kasos map sheet (Psimenos *et al.* 2017). Sample KAL02 is from a bed of red
163 radiolarian chert at the base of the radiolarite-pink limestone subunit located just above the
164 contact with gabbros and serpentinites (Figures 3b, 5a, 5e). Sample KAL03 is from a red
165 nodular radiolarian chert bed and was collected at the top of the radiolarite-pink limestone
166 subunit (Figures 3b, 5d).

167

168 Near Menetes, our sample locality KAM01 (Figure 2c, Table 2) is from a bed of radiolarite
169 interbedded with pink limestones, 150 m to the south of a well-exposed serpentinite outcrop at
170 the foot of Mount Homali (Figure 3b).

171

172 **4. Results**

173
174 The preservation of radiolarians extracted from our chert samples varies from moderate to
175 good at both the Lastos and Menetes locations. All of the radiolarian taxa and assemblages
176 identified in the samples are listed in Table 3. Morphotypes with biochronological
177 significance are illustrated in Figure 6.

178
179 KAL01 comprises sixteen identified taxa (Table 3). Among them, an assemblage composed
180 of *Archaeodictyomitra gracilis*, *Crucella euganea*, *Crucella messinae*, *Hiscocapsa asseni*,
181 *Hiscocapsa grutterinki* and *Pseudodictyomitra lodogaensis* corresponds to the unitary
182 associations zones (UAZ) 4–9 of O’Dogherty (1994) of early-late Aptian age. Other Early
183 Cretaceous species include *Cenodiscaella sphaeroconus*, *Homoeoparonaella* sp. cf. *speciosa*,
184 *Mesosaturnalis* sp., *Paronaella* sp., *Pseudocrucella* sp. aff. *kubischa*, *Pseudoeucyrtis*(?) *fuscus*,
185 *Stichomitra communis*, *Ultranapora* sp. cf. *durhami* and *Xitus* sp. aff. *spicularius*. Among
186 them, *Stichomitra communis* is known from the Aptian–Turonian interval (UAZ 42–46;
187 Goričan, 1994). We interpret the morphotype illustrated in Figure 6 (n° 14) as *Dictyomitra*
188 *montisserei*, which we consider to have a slightly longer age range than previously proposed
189 (UAZ 10–20 of Albian–Turonian age; O’Dogherty, 1994).

190
191 KAL02 is composed of eight radiolarian taxa (Table 3). The co-occurrence of *Crucella*
192 *messinae*, *Cyclastrum satoi*, *Dactyliosphaera lepta*, *Hexapyramis* sp. cf. *precedis*,
193 *Mesosaturnalis levis* and *Xitus spicularius* points to UAZ 11–12 of early–middle Albian age
194 (O’Dogherty, 1994). Some other taxa have longer age ranges, such as *Alievium* sp.
195 (Bajocian–Maastrichtian, O’Dogherty *et al.* 2009) and *Obeliscoites* sp. cf. *perspicuus* (UAZ
196 1–19, Barremian–Cenomanian; O’Dogherty, 1994).

197

198 KAL03 comprises ten radiolarian taxa (Table 3). *Alievum* sp. cf. *superbum*, *Crucella*
199 *cachensis*, and *Dictyomitra napaensis* are known as Turonian (Pessagno, 1976). Other taxa
200 have been found to co-occur in Turonian biozones, such as *Stichomitra communis* (UAZ
201 42–48 of late Aptian–Turonian; Goričan, 1994), *Dictyomitra montisserei* (UAZ 10–20,
202 Albian–Turonian; O’Dogherty, 1994), *Pseudodictyomitra pseudomacrocephala* (UAZ 10–21,
203 Albian–Turonian; O’Dogherty, 1994), and *Afens* sp. (Turonian–Campanian; O’Dogherty *et*
204 *al.* 2009).

205

206 KAM01 contains seven radiolarian taxa, including species reported from the biozonation of
207 O’Dogherty (1994), such as *Distylocapsa micropora* (UAZ 10–18) and *Thanarla brouweri*
208 (UAZ 1–12), corresponding to a middle Albian age. Other taxa are *Archaeospongoprunum*
209 *renaensis* (Albian; Pessagno, 1977), *Cenodiscaella tuberculatum* (early Cenomanian–?early
210 Turonian; Pessagno, 1977), *Staurosphaeretta* sp. (late Aptian–early Turonian; O’Dogherty *et*
211 *al.* 2009), *Pseudodictyomitra lodogaensis* (UAZ 42–46, late Aptian–late Albian; Goričan,
212 1994), and *Triactoma* sp. (early Pliensbachian–late Turonian; O’Dogherty *et al.* 2009).

213

214 In summary, the radiolarian ages established for the radiolarite-pink limestone subunit of the
215 Xindothio Unit are from base to top: early–late Aptian (KAL01; ~125–113 Ma; Cohen *et al.*
216 2013, updated 2018), early–middle Albian (KAL02; ~113–105 Ma), middle Albian (KAM01;
217 ~110–105 Ma), and Turonian (KAL03; ~93.9–89.8 Ma) (Figure 3a, b).

218

219 **5. Discussion**

220

221 **5.a. Comparison with previous microfossil ages**

222 The three Aptian and Albian radiolarian ages (~125–105 Ma) obtained at the base of the
223 radiolarite-pink limestone subunit at Lastos (KAL01, KAL02) and Menetes (KAM01) are
224 significantly younger than the Berriasian age (145–139.8 Ma) previously reported from the
225 same sequence (Davidson-Monett, 1974; Aubouin, Bonneau & Davidson, 1976). A similar
226 issue applied on Rhodes, where Danelian *et al.* (2001) established that Berriasian
227 calpionellids from the Profitis Ilias succession had been misidentified. This situation could
228 also be the case in Karpathos. Another hypothesis is that these calpionellids have been
229 reworked. In any case, based on results obtained in three sections in two separate areas
230 (Lastos and Menetes; Figure 3a, b), our data show that the radiolarites of the Xindothio Unit
231 are not Berriasian but rather Aptian–Albian.

232

233 Our younger radiolarian assemblage is Turonian (~93.9–89.8 Ma) and was obtained at the top
234 of the radiolarite-pink limestone subunit (KAL03). Foraminifera of similar age were reported
235 from the base of the platy limestone subunit (Davidson-Monett, 1974; Aubouin, Bonneau &
236 Davidson, 1976).

237

238 **5.b. Comparison with K-Ar isotopic ages**

239 K-Ar isotopic ages of Koepke, Seidel, & Kreuzer (2002) are shown in Table 1. At Menetes,
240 the age difference with the radiolarian data is minor, as the oldest isotopic age of 95.3 ± 4.2
241 Ma fits into the early Cenomanian (Cohen *et al.* 2013, updated 2018). At Lastos, the age
242 difference is greater: while radiolarians near the contact are Aptian, the oldest isotopic age is
243 middle Santonian (84.7 Ma, Table 1). To explain such a discrepancy, four hypotheses are
244 considered below:

245 1/ Aptian–Albian radiolarians were reworked and redeposited in younger Late Cretaceous
246 sediments. This process seems unlikely since the radiolarian assemblages do not show any
247 unusual mixing of incompatible taxa (Table 3). These assemblages also document a coherent

248 succession of upward-younging ages (Aptian > early–middle Albian > middle Albian >
249 Turonian; Figure 3a). In addition, the Turonian ages obtained independently with planktonic
250 foraminifera (Aubouin, Bonneau & Davidson, 1976) and radiolarians (this study) near the
251 contact between radiolarite-pink limestone and platy limestone subunits are both older than
252 the K-Ar isotopic ages of Koepke, Seidel, & Kreuzer (2002).

253 2/ The contact between mafic/ultramafic rocks and radiolarites is tectonic. However, this
254 hypothesis is not consistent with our field observations or those of Davidson-Monett (1974),
255 Aubouin, Bonneau & Davidson (1976) and Hatzipanagiotou (1988). The Xindothio Unit is
256 not an accretionary-type “broken formation” where subunits are chaotically juxtaposed.
257 Instead, it shows good reproducibility of the stratigraphic contact between the magmatic rocks
258 and the overlying radiolarian cherts, not only at Lastos but also at Menetes (Figure 2b, c). In
259 addition, there is good lateral continuity of the contact as shown by the parallel bedding of the
260 radiolarite-pink limestone subunit along strike (Figure 5b, c). One could argue that the
261 Karpathos ophiolite is dismembered and that mafic and ultramafic rocks may not be of the
262 same age as the overlying strata, but in a dismembered or *mélange*-type configuration, the
263 radiolarian-bearing sedimentary matrix should be closely synchronous or younger than any
264 such olistoliths, not older (Cordey, 1998).

265 3/ The Karpathos ophiolite has a longer age range than previously envisaged, i.e., spanning
266 the Early–Late Cretaceous, more precisely the Aptian–Santonian (from ~125–113 Ma to 84.7
267 Ma), representing the interval between the radiolarites overlying the ophiolite and the oldest
268 isotopic age in Lastos. In this case, the Xindothio radiolarites should be diachronous.
269 Considering the consistent Early Cretaceous ages from Lastos and Menetes areas (this study),
270 as well as the relatively small volumes of mafic and ultramafic rocks exposed on the island
271 (Figure 2a-c), we do not favour this hypothesis.

272 4/ Isotopic ages from Lastos have undergone some metamorphic overprint or are affected by
273 argon loss. This is, to us, the most likely cause of the chronological discrepancy, as both

274 phenomena can cause calculated K-Ar ages to be younger than the true ages of the dated
275 material (McDougall & Harrison, 1999). Similarly, it has been established that some of the
276 youngest Cretan ophiolites underwent such overprinting during the Late Cretaceous (95 Ma;
277 Koepke, Seidel & Kreuzer, 2002). Other authors have also shown that some Cretan isotopic
278 ages record the age of obduction rather than oceanic crust formation (Liati, Gebauer &
279 Fanning, 2004; Stampfli, Champod & Vandelli, 2010). In Turkey, Ar-Ar isotopic ages of the
280 metamorphic soles of the Lycian peridotites are mainly 92–90 Ma (Dilek *et al.* 1999), an age
281 range that is similar to the K-Ar isotopic ages on Karpathos. More recently, U-Pb ages on
282 zircons from the metamorphic sole of the Marmaris ophiolite (Lycian Nappes) have shown
283 that their tectonic emplacement occurred between 100.4 Ma and 93.5 Ma (Cenomanian),
284 suggesting an Early Cretaceous age for the ophiolite and the associated sedimentary rocks
285 (Güngör *et al.* 2018). Unfortunately, previous geochronological studies carried out on
286 Karpathos (Koepke, Kreuzer & Seidel, 1985; Hatzipanagiotou, 1991; Koepke, Seidel &
287 Kreuzer, 2002) did not document the precise locations for the K-Ar samples or indicate
288 whether the magmatic rocks were overlain by sedimentary strata, preventing comparative
289 sampling of sections.

290

291 We do not know to what extent the discrepancy between biochronological and
292 geochronological data observed on Karpathos is a localized problem or a larger issue
293 concerning Mesozoic ophiolites. Some isotopic ages established on these ophiolites using K-
294 Ar methods in the 1980s and 1990s probably need to be tested with more up-to-date methods
295 such as Ar-Ar and/or U-Pb, as carried out by and Liati, Gebauer & Fanning (2004) and Smith
296 (2006), who obtained zircon ages on hornblendites and gabbros from Cretan ophiolites, and
297 Parlak *et al.* (2013) who used hornblendes and zircons from ophiolites of the Tauride belt.

298

299

300 **6. Eastern Mediterranean correlations and implications for Neotethys evolution**

301

302 Tectonic reconstructions of the Eastern Mediterranean region imply the southward migration
303 of the Aegean fore-arc relative to Eurasia since Eocene times, a result of the rollback of
304 subducting African lithosphere (Zachariasse, Van Hinsbergen & Fortuin, 2008; Jolivet *et al.*
305 2013). Prior to the Paleogene, the paleogeographic evolution of the region has been described
306 by many authors at the scale of the Tethyan Realm (Robertson, 2002; Barrier & Vrielynck,
307 2008; Menant *et al.* 2016; Barrier *et al.* 2018), but these descriptions lack precision for the
308 islands of the Aegean Sea. Several hypotheses have been proposed for the Karpathos
309 ophiolite: initially, it was correlated with the ophiolites of Crete, both of which were
310 considered the easternmost remnants of the Pindos Nappes of continental Greece and the
311 Peloponnese (Figures 1, 7; Aubouin, Bonneau & Davidson, 1976; van Hinsbergen *et al.* 2005;
312 Papanikolaou, 2013; Ersoy *et al.* 2014; Pantopoulos & Zelilidis, 2014). Other authors have
313 interpreted the Karpathos and Rhodes ophiolites as southwestward extensions of the Lycian
314 Nappes exposed in southwestern Turkey (Figure 1; Robertson, 2002; Koepke, Seidel &
315 Kreuzer, 2002; van Hinsbergen *et al.* 2010). The ophiolites of Karpathos and Rhodes have
316 also been associated with the Late Cretaceous ophiolites of Cyprus, Syria, and Oman
317 (Koepke, Seidel & Kreuzer, 2002), hence as potential remnants of a basin located to the south
318 of Turkey, in a precursor position of the present-day Eastern Mediterranean Basin. In
319 summary, these conflicting interpretations consider the Karpathos ophiolite as an element of
320 the western Northern Neotethys (Pindos Zone), the central Northern Neotethys
321 (Izmir–Ankara–Erzincan suture and Lycian Nappes), or the Southern Neotethys
322 (Cyprus–Syria) (Figure 7).

323

324 A geological review of ophiolites exposed in the Aegean fore-arc (Figure 8a) shows that the
325 ophiolite of Karpathos is younger than those of Crete, where K-Ar isotopic ages range from

326 160 to 140 Ma (Middle–Late Jurassic) (Koepke, Seidel & Kreuzer, 2002; Liati, Gebauer &
327 Fanning, 2004). Notably, the youngest Cretan radiolarites are Late Jurassic in age (Stampfli,
328 Champod & Vandelli, 2010), similar to the Pindos radiolarites of continental Greece (De
329 Wever & Cordey, 1986). Another significant difference is that, on Karpathos, a shallow
330 marine Upper Eocene conglomerate overlies the dismembered ophiolite together with the
331 Mesozoic limestones (Kalilimni Unit) (Figures 2b, 5f), showing that these units were already
332 tectonically assembled while flysch deposition was still continuing in the Pindos Basin farther
333 west.

334

335 Our results indicate that the closest chronological and petrological similarities with the
336 ophiolite of Karpathos are found in southwestern Turkey, more specifically within the Lycian
337 Nappes (de Graciansky, 1967; Collins & Robertson, 1997, 2003; Dilek *et al.* 1999; Robertson,
338 2002). In the Lycian Mélange, Danelian *et al.* (2006) documented Jurassic and Early
339 Cretaceous radiolarian cherts. In the Marmaris ophiolite, the youngest sediments associated
340 with the ophiolite are pre-Cenomanian (Güngör *et al.* 2018).

341

342 Many authors have established a link between the Lycian Nappes and the
343 Izmir–Ankara–Erzincan Suture Zone situated to the north of the Menderes metamorphic
344 complex (Figure 8a) (Robertson & Pickett, 2000; Okay *et al.* 2001; Collins & Robertson,
345 2003; Robertson *et al.* 2004). The Izmir–Ankara–Erzincan Suture Zone is itself considered a
346 remnant of the Northern Neotethyan Ocean (Danelian *et al.* 2006) and records a long history
347 of radiolarite accumulation. In the Central Sakarya Zone, the Dağköplü Mélange includes
348 several slices of mid-ocean ridge metabasalts (MORB-type) that alternate with radiolarites
349 dated to the Middle–Late Jurassic (Bathonian–Tithonian), Early Cretaceous
350 (Hauterivian–Aptian) and early Late Cretaceous (Cenomanian) (Göncüoğlu *et al.* 2000,
351 2001). Farther east in the Ankara Mélange, blocks of radiolarite associated with gabbro and

352 pink micritic limestone are dated as Late Triassic, Early Jurassic, Late Jurassic and Early
353 Cretaceous, including Aptian and Albian strata such as on Karpathos (Bragin & Tekin, 1996).
354 As in the Dağküllü Mélange, the youngest radiolarites of the Ankara Mélange are
355 Cenomanian (Bragin & Tekin, 1996). Previous authors noted great similarities in both
356 petrography and trace elements between Karpathos and Rhodes mafic and ultramafic rocks
357 and those of western Turkey, emphasizing the depleted nature of the peridotites and the
358 geochemistry of dykes that are typical of supra-subduction zone ophiolites (Koepke, Seidel &
359 Kreuzer, 2002).

360

361 Farther south in the Antalya Complex, MOR-type (mid-ocean ridge) volcanic rocks are
362 overlain by Late Jurassic–Early Cretaceous radiolarian cherts (Robertson & Woodcock, 1982;
363 Yilmaz, 1984; Robertson, 2002), partly coeval with Karpathos radiolarites. However, the
364 Antalya Complex records a distinct geological history and tectonic setting of an oceanic
365 domain located to the south of the Tauride carbonate platform (Figure 7; Barrier & Vrielynck,
366 2008; Robertson, Parlak & Ustaömer, 2012; Barrier *et al.* 2018).

367

368 The ophiolites of Karpathos and Rhodes have also been correlated with the Late Cretaceous
369 ophiolites of Cyprus, Syria, and Oman (Koepke, Seidel & Kreuzer, 2002) and hence
370 interpreted as potential remnants of the Southern Neotethys (Figure 7). However, this
371 hypothesis is not supported by the tectonic interpretations that imply that the emplacement of
372 the Karpathos and Rhodes ophiolites proceeded southward during the closure of a basin
373 located to the north of Turkey (van Hinsbergen *et al.* 2010; Schettino & Turco, 2011).

374

375 In summary, the comparison of these various interpretations suggests that the Karpathos
376 ophiolite originated in the central Northern Neotethys (Figure 7; Dilek *et al.* 1999; Robertson,
377 2002; Barrier & Vrielynck, 2008; Menant *et al.* 2016; Barrier *et al.* 2018) and is linked to the

378 Lycian Nappes and their root, the Izmir–Ankara–Erzincan Suture Zone. A slight difference
379 lies in the age of the youngest radiolarites between these units: while Karpathos radiolarites
380 are Aptian–Albian (125–100.5 Ma; Cohen *et al.* 2013, updated 2018), the youngest
381 radiolarites of the Lycian Nappes and the Izmir–Ankara–Erzincan Suture Zone are
382 consistently Cenomanian (100.5–93.9 Ma). In addition, the age range represented by the
383 ophiolite is much shorter on Karpathos (late Early Cretaceous). This suggests that the
384 Karpathos ophiolite may be a remnant of a short-lived segment of the Northern Neotethys that
385 was originally located in the westernmost part of the Izmir–Ankara–Erzincan Suture Zone
386 (Figures 7, 8). The convergence and closure of the Northern Neotethys during the Paleogene
387 then led to the thrusting of ophiolite-bearing tectonic slices over the Karpathos
388 parautochthonous carbonate platform, similar to the Lycian Nappes over Rhodes (Figure 8b).
389 Eventually, the southward movement of the Aegean arc during the Neogene distorted the
390 original Paleogene configuration, separating Karpathos farther from the ancient
391 Izmir–Ankara–Erzincan root zone.

392

393

394 **7. Conclusions**

395

396 Our study documents the occurrence of Early Cretaceous radiolarians in sedimentary rocks
397 overlying mafic and ultramafic rocks on the island of Karpathos, with the following
398 implications:

399 - The older radiolarian assemblage provides a minimum Aptian age (~125–113 Ma) for the
400 ophiolite, while the younger assemblage indicates that the top of the radiolarite-pink
401 limestone subunit is Turonian (~93.9–89.8 Ma). The Aptian and Albian radiolarian ages raise
402 questions regarding the accuracy of a Berriasian age obtained previously from a single
403 calpionellid assemblage in the same subunit.

404 - The oldest radiolarian ages (late Early Cretaceous) are significantly older than those
405 proposed for the ophiolite using K-Ar geochronology (Late Cretaceous, from 95.3 ± 4.2 Ma to
406 81.2 ± 1.6 Ma), suggesting that these isotopic ages may have been reset by Late Cretaceous
407 metamorphism, or were affected by argon loss.

408 - The Karpathos ophiolite should not be associated with the Pindos Nappes or the ophiolites
409 of Cyprus or Syria but rather with the Lycian Nappes and their root located in the
410 Izmir–Ankara–Erzincan Suture Zone, possibly representing the westernmost part of this
411 structure. Consequently, the ophiolite of Karpathos is likely to be a remnant of the Northern
412 Neotethys, not of the Pindos Ocean or the proto-Eastern Mediterranean Basin.

413 - From an analytical viewpoint, our study suggests that previous K-Ar isotopic ages obtained
414 from the ophiolites of the Mediterranean region should be revised with more recent and
415 accurate methods (Ar-Ar, U-Pb), particularly for geological units that have been affected by
416 syn- or post-emplacement metamorphism and deformation.

417

418

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429

430 **Declaration of Interest**

431 None

432

433 **Supplementary Material**

434 Appendix “Pioneering studies on Karpathos” available online at

435 <http://journals.cambridge.org/geo>

436

437

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693

694 **Figure captions**

695 **Figure 1** (Colour online). Structural map of the southern Aegean region with location of the
696 island of Karpathos (black frame) and the distribution of ophiolites in southern Greece and
697 western Turkey. Compiled from Bornovas & Rontogianni-Tsiabaou (1983), Jolivet *et al.*
698 (2004, 2013), van Hinsbergen *et al.* (2005, 2010), Stampfli, Champod & Vandelli (2010),
699 Ersoy *et al.* (2014), and Gürer *et al.* (2018). The ‘eastern’ and ‘western’ ophiolite regions
700 refer to the classification by Robertson (2002). IAE: Izmir–Ankara–Erzincan Suture Zone.

701

702 **Figure 2.** (a) Geological and structural map of Karpathos (modified after Aubouin, Bonneau
703 & Davidson, 1976). (b) Geological map of the Lastos area and location of the radiolarian
704 localities KAL01 (section ‘North Lastos road’), KAL02 and KAL03 (section ‘Hill 730 m’
705 outlined by a white band). Topography from the Karpathos-Kasos map sheet 1:30 000
706 (Psimenos *et al.* 2017). Geology based on Christodoulou (1968), Davidson-Monett (1974),
707 Aubouin, Bonneau & Davidson (1976), and personal field observations. (c) Geological map
708 of the Menetes area and location of the radiolarian locality KAM01. Topography from the
709 Karpathos-Kasos map sheet 1:30 000 (Psimenos *et al.* 2017). Geology from the Karpathos
710 map sheet (Christodoulou, 1968).

711

712 **Figure 3.** (Colour online) (a) Synthetic lithostratigraphic column of the Xindothio Unit
713 succession (modified after Aubouin, Bonneau & Davidson, 1976). Basal radiolarites
714 overlying mafic/ultramafic rocks are presently dated as Aptian (this study) instead of
715 Berriasian (Aubouin, Bonneau & Davidson, 1976). Isotopic ages are from Cohen *et al.* (2013,
716 updated 2018). Dotted lines (left): probable positions of stage boundaries based on
717 biochronological data; red line: thrust fault at the base of mafic/ultramafic rocks; dotted lines
718 (right): boundaries between subunits. (b) Sections in the Lastos and Menetes areas and
719 stratigraphic positions of the radiolarian samples.

720

721 **Figure 4.** (Colour online) Schematic cross-section of the south Lastos area including section
722 ‘Hill 730 m’ and position of samples KAL02 and KAL03 close to the contact with
723 mafic/ultramafic rocks (modified after Aubouin, Bonneau & Davidson, 1976). Note that the
724 Xindothio Unit is structurally situated above the dolomitic limestones of the Kalilimni Unit
725 but underwent Cenozoic extension and normal faulting visible in the southwestern part of the
726 section.

727

728 **Figure 5.** Field views of the studied Karpathos units and localities (see Fig. 2b for locations
729 of photographs). (a) Overview of section ‘Hill 730 m’ in Lastos (Figs. 2b, 3b, 4) and subunits
730 within the Xindothio Unit (Fig. 3); in the distance towards the west: parautochthonous
731 limestone exposures of Kalilimni Unit; Mount Kalilimni (1215 m) is the highest point on the
732 island. (b) Exposure of serpentinite (white arrows) overlain by the red radiolarite-pink
733 limestone subunit along the north Lastos road (Fig. 2b). White dashed line: contact between
734 ultramafic and sedimentary rocks. White dotted lines: bedding of radiolarite and pink
735 limestone, parallel to the contact between ultramafic and sedimentary rocks. (c) Close-up of
736 the contact between serpentinite and radiolarite (dashed line) along the north Lastos road near
737 locality KAL01 (Fig. 2b). (d) Pink limestone and chert nodules (white arrows) exposed in the

738 middle part of section 'Hill 730 m' (total thickness 1 m). (e) Close-up of thick radiolarite beds
739 at the base of section 'Hill 730 m' (Lastos, Figs. 2b, 3, 4). (f) Exposure of the Lastos
740 conglomerate (Eocene) displaying a variety of pebbles of radiolarite (white arrows),
741 serpentinite (yellow arrows) and limestones from the underlying Kalilimni and Xindothio
742 units.

743

744 **Figure 6.** Scanning electron microphotographs (SEM) of radiolarian taxa from Lastos (KAL)
745 and Menetes (KAM). For each sample: age and radiolarian assemblage. For each picture:
746 radiolarian taxon, scale length.

747 - Sample KAL03 (Turonian); 1. *Pseudodictyomitra pseudomacrocephala* (SQUINABOL)
748 (210 µm); 2. *Dictyomitra napaensis* PESSAGNO (200 µm); 3. *Dictyomitra montisserei*
749 (SQUINABOL) (220 µm); 4. *Stichomitra communis* (SQUINABOL) (190 µm); 5. *Afens* sp.
750 (200 µm); 6. *Crucella cachensis* PESSAGNO (180 µm); 7. *Patellula verteroensis*
751 (PESSAGNO) (160 µm).

752 - Sample KAL01 (Aptian); 8. *Cenodiscaella sphaeroconus* (RÜST) (200 µm); 9.
753 *Homoeoparonaella* sp. cf. *speciosa* (PARONA) (320 µm); 10. *Crucella messinae*
754 PESSAGNO (240 µm); 11. *Crucella euganea* SQUINABOL (240 µm); 12. *Ultranapora* sp.
755 cf. *durhami* PESSAGNO (140 µm); 13. *Pseudodictyomitra lodogaensis* PESSAGNO (180
756 µm); 14. *Dictyomitra montisserei* (SQUINABOL) (180 µm); 15. *Xitus* sp. aff. *spicularius*
757 (ALIEV) (210 µm); 16. *Archaeodictyomitra gracilis* (SQUINABOL) (200 µm); 17.
758 *Archaeodictyomitra gracilis* (SQUINABOL) (180 µm); 18. *Hiscocapsa asseni* (TAN) (120
759 µm); 19. *Hiscocapsa grutterinki* (TAN) (150 µm).

760 - Sample KAL02 (early–middle Albian); 20. *Obeliscoites* sp. cf. *perspicuus* (SQUINABOL)
761 (180 µm); 21. *Xitus spicularius* (ALIEV) (190 µm); 22. *Dactyliosphaera lepta* FOREMAN
762 (200 µm); 23. *Dactyliosphaera* sp. cf. *lepta* FOREMAN (200 µm); 24. *Mesosaturnalis* sp.

763 (190 μm); 25. *Hexapyramis* sp. cf. *precedis* JUD (190 μm); 26. *Cyclastrum satoi*
764 (TUMANDA) (180 μm).
765 - Sample KAM01 (middle Albian); 27. *Cenodiscaella tuberculatum* (DUMITRICA) (160
766 μm); 28. *Staurosphaeretta* sp. (130 μm); 29. *Thanarla brouweri* (TAN) (120 μm); 30.
767 *Archaeospondoprumum renaensis* PESSAGNO (180 μm); 31. *Distylocapsa micropora*
768 (SQUINABOL) (180 μm).

769

770 **Figure 7.** Schematic paleogeographic map of western Neotethyan basins in the Cretaceous.
771 Compiled from Barrier & Vrielynck (2008), Robertson, Parlak & Ustaömer (2012), Menant *et*
772 *al.* (2016), Barrier *et al.* (2018), Maffione & van Hinsbergen (2018). Star: hypothetical
773 position of Karpathos ophiolite prior to obduction. Note that the ophiolites and the tectonic
774 nappes depicted in the diagram have been emplaced diachronously: they just indicate the
775 initial locations and relationships to the surrounding oceanic basins.

776

777 **Figure 8.** (a) Map of the Aegean region prior to the complete southward migration of the
778 Aegean fore-arc during the Neogene (modified after Garfunkel, 2004). The map shows the
779 position of the ophiolites and the extensions of the Pindos and Lycian nappes, which have
780 been proposed as potential sources for the ophiolite-bearing units of Crete, Karpathos, and
781 Rhodes. A-B: cross-section shown in (b). Isotopic ages, Crete: Koepke, Seidel & Kreuzer
782 (2002); Liati, Gebauer & Fanning (2004). Karpathos and Rhodes: Koepke, Seidel & Kreuzer
783 (2002). Southwestern Turkey: Dilek *et al.* (1999); Güngör *et al.* (2018) (see references for age
784 ranges, error margins and local distribution). Age of radiolarites, Crete: Stampfli, Champod &
785 Vandelli (2010); Turkey: Danelian *et al.* (2006); Karpathos: this study. IAE:
786 Izmir–Ankara–Erzincan Suture Zone. (b) Cross-section A-B (Fig. 8a) from the Eastern
787 Mediterranean Basin to the Izmir–Ankara–Erzincan Suture Zone (modified after van

788 Hinsbergen *et al.* 2010), illustrating the southward thrusting of the Lycian Nappes and related
789 ophiolites over Rhodes and Karpathos.
790

791 Table 1. K-Ar isotopic ages in the Lastos and Menetes areas (Koepke, Seidel & Kreuzer,
 792 2002) and correlation with geological stages (Cohen *et al.* 2013, updated 2018).

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	K-Ar age (Ma)	Error (Ma)	Lower limit	Upper limit
Lastos	83.1	± 1.6	84.7	81.5
			middle Santonian	early Campanian
	81.2	± 1.6	82.8	79.6
			early Campanian	middle Campanian
Menetes	91.9	± 3.5	95.4	88.4
			late Cenomanian	early Coniacian
	95.3	± 4.2	99.5	91.1
			early Cenomanian	middle Turonian
	88.8	± 5	93.8	83.8
			basal Turonian	late Santonian

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Table 2. Geographic coordinates of radiolarian samples from Karpathos.

797

Lastos	KAL01	N 35° 34' 51.90"	E 27° 08' 35.96"
	KAL02	N 35° 34' 16.08"	E 27° 08' 26.14"
	KAL03	N 35° 34' 20.66"	E 27° 08' 30.57"
Menetes	KAM01	N 35° 29' 28.59"	E 27° 09' 3.84"

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Table 3. Radiolarian taxa and assemblages from Karpathos.

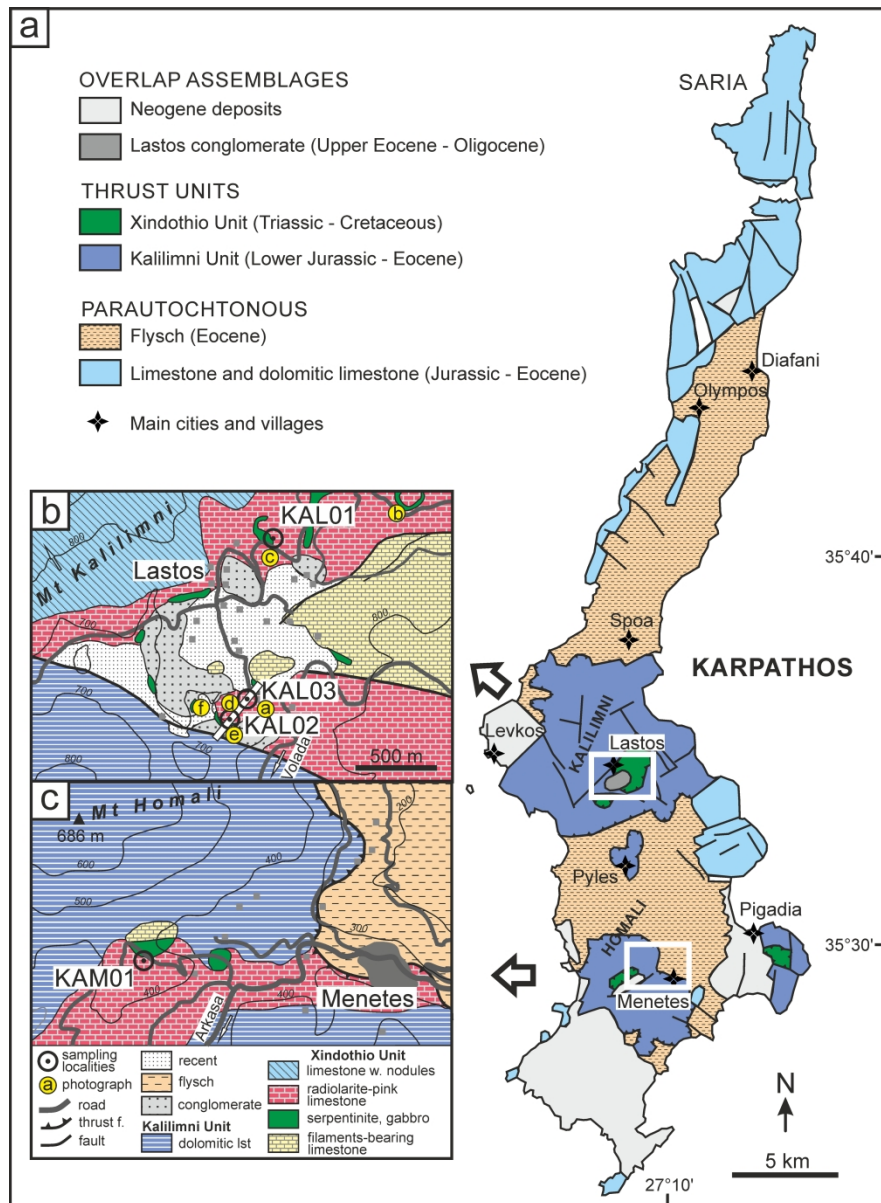
Taxa	KAL01	KAL02	KAL03	KAM01
<i>Afens</i> sp.			x	
<i>Alievium</i> sp.		x		
<i>Alievium</i> sp. cf. <i>superbum</i> (SQUINABOL)			x	
<i>Archaeodictyomitra gracilis</i> (SQUINABOL)	x			
<i>Archaeospongoprimum renaensis</i> PESSAGNO				x
<i>Archaeospongoprimum</i> sp.			x	
<i>Cenodiscaella sphaeroconus</i> (RÜST)	x			
<i>Cenodiscaella tuberculatum</i> (DUMITRICA)				x
<i>Crucella cachensis</i> PESSAGNO			x	
<i>Crucella euganea</i> SQUINABOL	x			
<i>Crucella messinae</i> PESSAGNO	x	x		
<i>Cyclastrum satoi</i> (TUMANDA)		x		
<i>Dactyliosphaera leptota</i> FOREMAN		x		
<i>Dictyomitra montisserei</i> (SQUINABOL)	x		x	
<i>Dictyomitra napaensis</i> PESSAGNO			x	
<i>Distylocapsa micropora</i> SQUINABOL				x
<i>Falsocromyodrymus</i> sp.			x	
<i>Hexapyramis</i> sp. cf. <i>precedis</i> JUD		x		
<i>Hiscocapsa asseni</i> (TAN)	x			
<i>Hiscocapsa grutterinki</i> (TAN)	x			
<i>Homoeoparonaella</i> sp. cf. <i>speciosa</i> (PARONA)	x			
<i>Mesosaturnalis levis</i> (DONOFRIO & MOSTLER)		x		
<i>Mesosaturnalis</i> sp.	x			
<i>Obeliscoites</i> sp. cf. <i>perspicuus</i> (SQUINABOL)		x		
<i>Paronaella</i> sp.	x			
<i>Patellula verteroensis</i> (PESSAGNO)			x	
<i>Pseudocrucella</i> sp. aff. <i>kubischa</i> EMPSON-MORIN	x			
<i>Pseudodictyomitra lodogaensis</i> PESSAGNO	x			x
<i>Pseudodictyomitra pseudomacrocephala</i> (SQUINABOL)			x	
<i>Pseudoeucyrtis</i> (?) <i>fuscus</i> JUD	x			
<i>Staurosphaeretta</i> sp.				x
<i>Stichomitra communis</i> (SQUINABOL)	x		x	
<i>Thanarla brouweri</i> (TAN)				x
<i>Triactoma</i> sp.				x
<i>Ultranapora</i> sp. cf. <i>durhami</i> PESSAGNO	x			
<i>Xitus</i> sp. aff. <i>spicularius</i> (ALIEV)	x			
<i>Xitus spicularius</i> (ALIEV)		x		

802



Figure 1 (Colour online). Structural map of the southern Aegean region with location of the island of Karpathos (black frame) and the distribution of ophiolites in southern Greece and western Turkey. Compiled from Bornovas & Rontogianni-Tsiabaou (1983), Jolivet *et al.* (2004, 2013), van Hinsbergen *et al.* (2005, 2010), Stampfli, Champod & Vandelli (2010), Ersoy *et al.* (2014), and Güreş *et al.* (2018). The 'eastern' and 'western' ophiolite regions refer to the classification by Robertson (2002). IAE: Izmir–Ankara–Erzincan Suture Zone.

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45 Figure 2. (a) Geological and structural map of Karpathos (modified after Aubouin, Bonneau & Davidson, 1976). (b) Geological map of the Lastos area and location of the radiolarian localities KAL01 (section 'North Lastos road'), KAL02 and KAL03 (section 'Hill 730 m' outlined by a white band). Topography from the Karpathos-Kasos map sheet 1:30 000 (Psimenos *et al.* 2017). Geology based on Christodoulou (1968), Davidson-Monett (1974), Aubouin, Bonneau & Davidson (1976), and personal field observations. (c) Geological map of the Menetes area and location of the radiolarian locality KAM01. Topography from the Karpathos-Kasos map sheet 1:30 000 (Psimenos *et al.* 2017). Geology from the Karpathos map sheet (Christodoulou, 1968).

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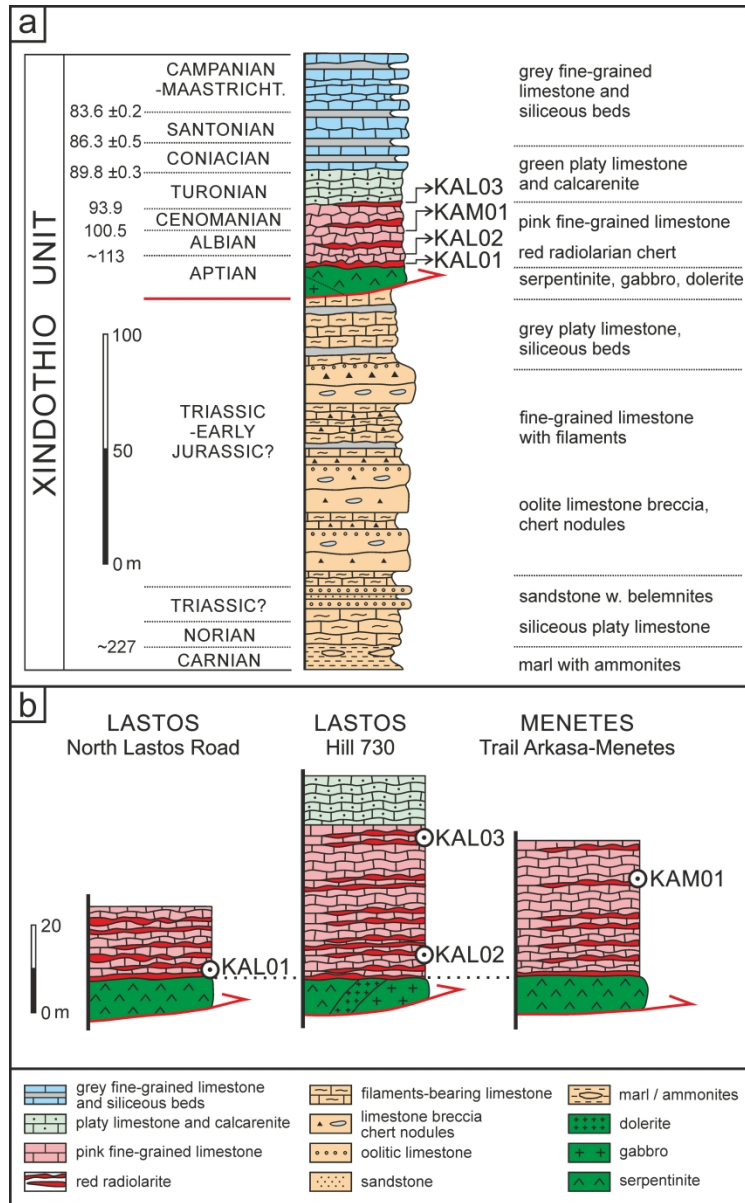


Figure 3. (Colour online) (a) Synthetic lithostratigraphic column of the Xindothio Unit succession (modified after Aubouin, Bonneau & Davidson, 1976). Basal radiolarites overlying mafic/ultramafic rocks are presently dated as Aptian (this study) instead of Berriasian (Aubouin, Bonneau & Davidson, 1976). Isotopic ages are from Cohen *et al.* (2013, updated 2018). Dotted lines (left): probable positions of stage boundaries based on biochronological data; red line: thrust fault at the base of mafic/ultramafic rocks; dotted lines (right): boundaries between subunits. (b) Sections in the Lastos and Menetes areas and stratigraphic positions of the radiolarian samples.

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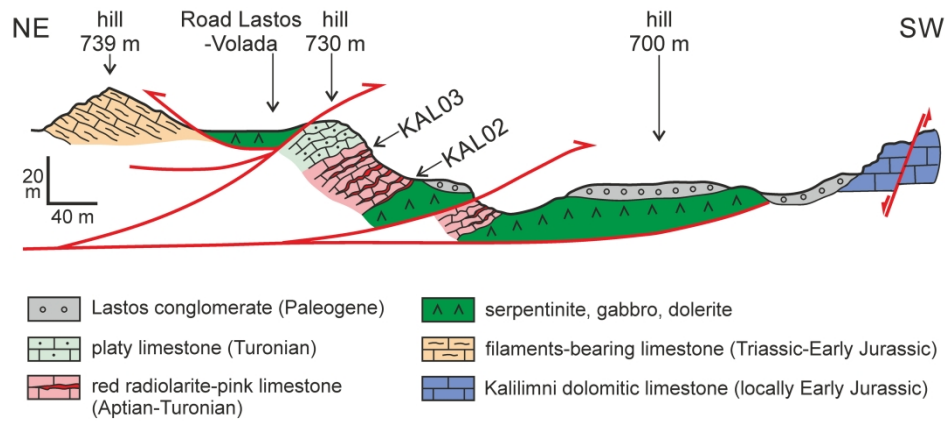


Figure 4. (Colour online) Schematic cross-section of the south Lastos area including section 'Hill 730 m' and position of samples KAL02 and KAL03 close to the contact with mafic/ultramafic rocks (modified after Aubouin, Bonneau & Davidson, 1976). Note that the Xindothio Unit is structurally situated above the dolomitic limestones of the Kalilimni Unit but underwent Cenozoic extension and normal faulting visible in the southwestern part of the section.

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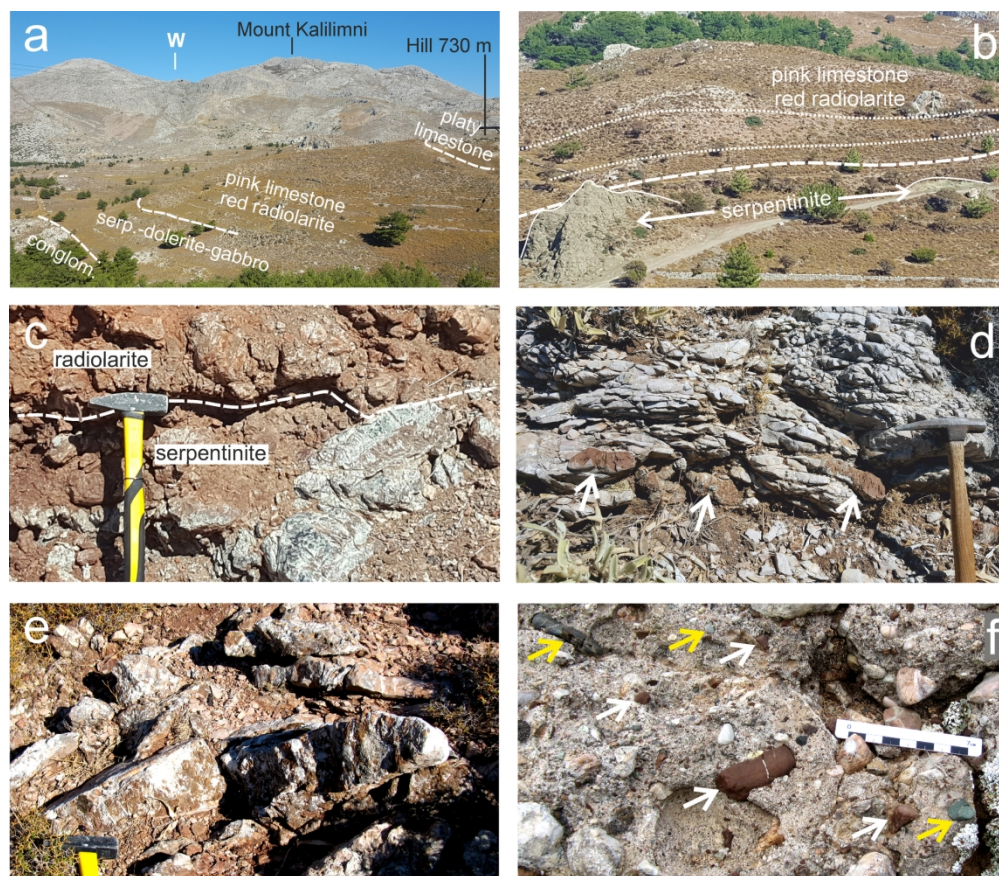


Figure 5. Field views of the studied Karpathos units and localities (see Fig. 2b for locations of photographs). (a) Overview of section 'Hill 730 m' in Lastos (Figs. 2b, 3b, 4) and subunits within the Xindothio Unit (Fig. 3); in the distance towards the west: parautochthonous limestone exposures of Kalilimni Unit; Mount Kalilimni (1215 m) is the highest point on the island. (b) Exposure of serpentinite (white arrows) overlain by the red radiolarite-pink limestone subunit along the north Lastos road (Fig. 2b). White dashed line: contact between ultramafic and sedimentary rocks. White dotted lines: bedding of radiolarite and pink limestone, parallel to the contact between ultramafic and sedimentary rocks. (c) Close-up of the contact between serpentinite and radiolarite (dashed line) along the north Lastos road near locality KAL01 (Fig. 2b). (d) Pink limestone and chert nodules (white arrows) exposed in the middle part of section 'Hill 730 m' (total thickness 1 m). (e) Close-up of thick radiolarite beds at the base of section 'Hill 730 m' (Lastos, Figs. 2b, 3, 4). (f) Exposure of the Lastos conglomerate (Eocene) displaying a variety of pebbles of radiolarite (white arrows), serpentinite (yellow arrows) and limestones from the underlying Kalilimni and Xindothio units.

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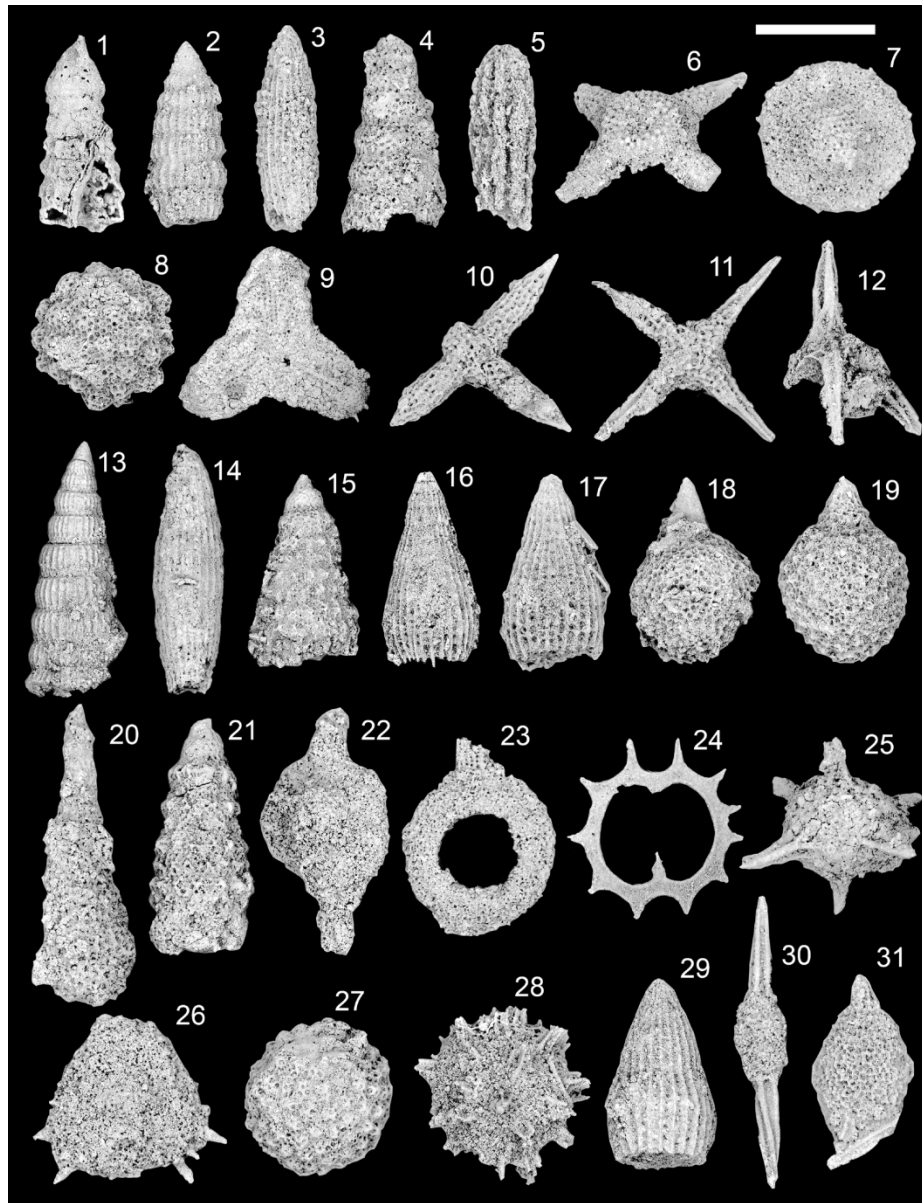


Figure 6. Scanning electron microphotographs (SEM) of radiolarian taxa from Lastos (KAL) and Menetes (KAM). For each sample: age and radiolarian assemblage. For each picture: radiolarian taxon, scale length.

Sample KAL03 (Turonian): 1. *Pseudodictyomitra pseudomacrocephala* (SQUINABOL) (210 μm); 2. *Dictyomitra napaensis* PESSAGNO (200 μm); 3. *Dictyomitra montisserei* (SQUINABOL) (220 μm); 4. *Stichomitra communis* (SQUINABOL) (190 μm); 5. *Afens* sp. (200 μm); 6. *Crucella cachensis* PESSAGNO (180 μm); 7. *Patellula verteroensis* (PESSAGNO) (160 μm). Sample KAL01 (Aptian): 8. *Cenodiscaella sphaeroconus* (RÜST) (200 μm); 9. *Homoeoparonaella* sp. cf. *speciosa* (PARONA) (320 μm); 10. *Crucella messinae* PESSAGNO (240 μm); 11. *Crucella euganea* SQUINABOL (240 μm); 12. *Ultranapora* sp. cf. *durhami* PESSAGNO (140 μm); 13. *Pseudodictyomitra lodogaensis* PESSAGNO (180 μm); 14. *Dictyomitra montisserei* (SQUINABOL) (180 μm); 15. *Xitus* sp. aff. *spicularius* (ALIEV) (210 μm); 16. *Archaeodictyomitra gracilis* (SQUINABOL) (200 μm); 17. *Archaeodictyomitra gracilis* (SQUINABOL) (180 μm); 18. *Hiscocapsa asseni* (TAN) (120 μm); 19. *Hiscocapsa grutterinki* (TAN) (150 μm). Sample KAL02 (early–middle Albian): 20. *Obeliscoites* sp. cf. *perspicuus* (SQUINABOL) (180 μm); 21. *Xitus spicularius* (ALIEV) (190 μm); 22. *Dactyliosphaera lepta* FOREMAN (200 μm); 23. *Dactyliosphaera* sp. cf. *lepta* FOREMAN (200 μm); 24.

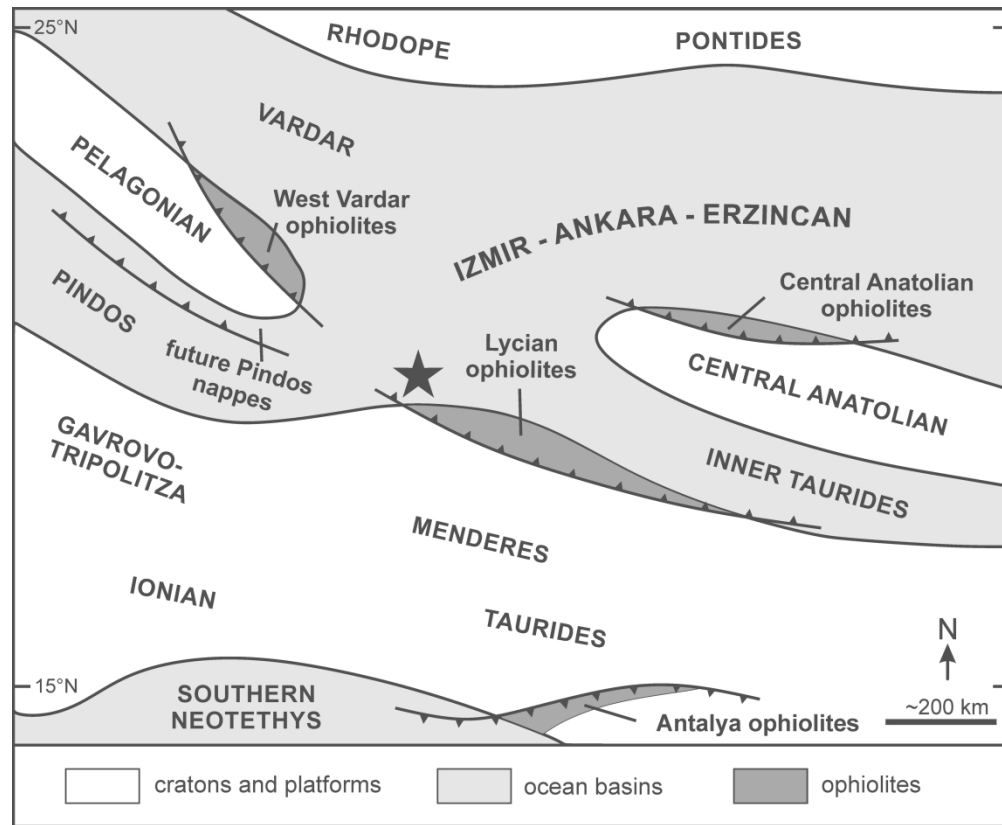


Figure 7. Schematic paleogeographic map of western Neotethyan basins in the Cretaceous. Compiled from Barrier & Vrielynck (2008), Robertson, Parlak & Ustaömer (2012), Menant *et al.* (2016), Barrier *et al.* (2018), Maffione & van Hinsbergen (2018). Star: hypothetical position of Karpathos ophiolite prior to obduction. Note that the ophiolites and the tectonic nappes depicted in the diagram have been emplaced diachronously: they just indicate the initial locations and relationships to the surrounding oceanic basins.

149x123mm (600 x 600 DPI)

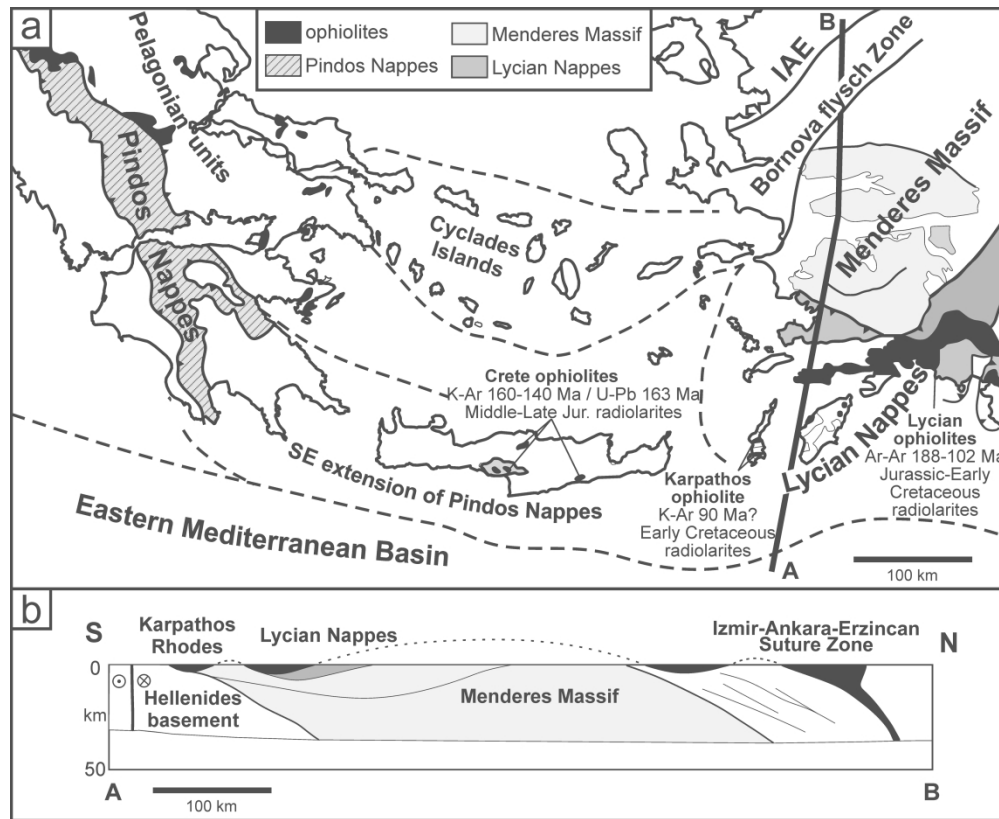


Figure 8. (a) Map of the Aegean region prior to the complete southward migration of the Aegean fore-arc during the Neogene (modified after Garfunkel, 2004). The map shows the position of the ophiolites and the extensions of the Pindos and Lycian nappes, which have been proposed as potential sources for the ophiolite-bearing units of Crete, Karpathos, and Rhodes. A-B: cross-section shown in (b). Isotopic ages, Crete: Koepke, Seidel & Kreuzer (2002); Liati, Gebauer & Fanning (2004). Karpathos and Rhodes: Koepke, Seidel & Kreuzer (2002). Southwestern Turkey: Dilek *et al.* (1999); Güngör *et al.* (2018) (see references for age ranges, error margins and local distribution). Age of radiolarites, Crete: Stampfli, Champod & Vandelli (2010); Turkey: Danelian *et al.* (2006); Karpathos: this study. IAE: Izmir–Ankara–Erzincan Suture Zone. (b) Cross-section A-B (Fig. 8a) from the Eastern Mediterranean Basin to the Izmir–Ankara–Erzincan Suture Zone (modified after van Hinsbergen *et al.* 2010), illustrating the southward thrusting of the Lycian Nappes and related ophiolites over Rhodes and Karpathos.

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