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1 **Dextral strike-slip and normal faulting during middle Miocene back-arc**
2 **extension and westward Anatolia extrusion in Central Greece**

3

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14 **Key Points**

- 15 • *Central Greece middle Miocene basins are controlled by the coeval activity of NE-*
16 *striking dextral strike-slip and NW-striking normal faults*
- 17 • *The middle Miocene Pelagonian dextral strike-slip fault accommodated the differential*
18 *extension rate between the Cyclades and Central Greece*
- 19 • *Plio-Quaternary deformation is controlled by E-striking normal faults and NW-striking*
20 *fault zones, forming oblique rifts (Evia, Corinth)*

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33 **Abstract**

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Present-day Aegean tectonics is marked by the interplay between Hellenic slab rollback and Anatolia extrusion, explaining the formation of extensional basins and dextral strike-slip faults. We aim to constrain, with structural analysis and low-temperature data, middle Miocene activity of dextral strike-slip and normal faults in Central Greece. We show that onshore middle Miocene basins are controlled by both NW-striking normal faults and NE-striking dextral strike-slip faults. E-striking normal faults developed during the Plio-Quaternary inside pre-existing NW-striking fault zones. Stress tensor calculations show that in middle Miocene, NW-striking normal faults and NE-striking dextral faults are compatible, confirming their coeval activity. In contrast, the Plio-Quaternary stress tensor suggests an almost N-S radial extension, which is not compatible with NE-striking dextral faults in Central Greece. Apatite Fission Track data additionally constrain middle Miocene local cooling near NW-striking normal faults. They also support a difference in the amount of exhumation between Central Greece and the Cyclades, likely accommodated by the Pelagonian dextral strike-slip fault. We propose that in the middle Miocene, the co-existence of dextral strike-slip and normal faults is associated with an almost N-S extension related to trench retreat and an E-W compression related to westward extrusion of Anatolia. The progressive trench curvature during rollback implies block rotation, accommodated by the Pelagonian fault, and subsequent normal fault and extensional stress rotation. During the Plio-Quaternary, a change in extensional direction from NE-SW to N-S implies the formation of E-striking normal faults inside NW-striking fault zone, defining oblique rift systems.

69 **1. Introduction**

70

71 Present-day Aegean tectonics activity is marked by the interplay between westward Anatolian extrusion
72 and southward Hellenic slab rollback (Fig. 1, inset for GPS velocity field - Reilinger et al., 2006;
73 Hollenstein et al., 2008; Pérouse et al., 2012). The Aegean domain is the upper plate of the Hellenic
74 subduction that is active since Jurassic times (Clift and Dixon, 1998; Papanikolaou, 2013). The lower
75 subducting plate was composed of three main micro-continents separated by two main oceans or deep
76 basins. Subduction led to the progressive accretions of these continental terranes and the formation of
77 the nappe stack that characterizes the Aegean domain; from bottom to top: Adria with some fragments
78 of Pindos ocean, Pelagonia and minor fragments of Vardar ocean in Rhodope (Fig. 1 – Aubouin, 1965;
79 Papanikolaou, 1997, 2013). Southward Hellenic subduction slab rollback caused subsequent upper plate
80 extension that is proposed to be mainly accommodated by several low-angle detachment systems with
81 the formation of Metamorphic Core Complexes (MCC – Lister et al., 1984; Gautier et al., 1993;
82 Vandenberg and Lister, 1996; Faccenna et al., 2003; Jolivet, 2003; Jolivet et al., 2010a; Brun and
83 Faccenna, 2008; Brun et al., 2016; Brun and Sokoutis, 2018; Grasemann et al., 2012, 2018). From the
84 middle Miocene to present, trench retreat accelerated and led to both ongoing activity of low-angle
85 normal faults (Avigad and Garfunkel, 1989; Forster and Lister, 1999; Tschegg and Grasemann, 2009;
86 Krohe et al., 2010; Iglseder et al., 2011) and the development of NW-striking high-angle normal faults
87 (e.g parallel to the retreating trench) and extensional basins at the scale of the whole Aegean (Fig. 1,
88 orange basins- Mascle and Martin, 1990; Brun et al., 2016). In this context, Central Greece, the
89 Peloponnese and the North West Cyclades rotated clockwise by 25 to 50° (Horner and Freeman, 1983;
90 Kissel et al., 1986, 2003; Duermeijer, 2000; van Hinsbergen et al., 2005, 2006; Bradley et al., 2013)
91 around the Scutari Pec pole (Speranza et al., 1992), and the South East Cyclades rotated counter-
92 clockwise (~30° - van Hinsbergen et al., 2007, 2010; van Hinsbergen and Schmid, 2012 - Fig. 1).

93 During the Plio-Quaternary, the formation of the large dextral North Anatolian strike-slip Fault (NAF)
94 accommodating westward Anatolian extrusion, is associated with plate kinematics re-organisation and
95 a modification of Aegean extension (Fig. 1 - Armijo et al., 1999, 2004; Hubert-Ferrari et al., 2002,
96 2003; Flerit et al., 2004). This plate re-organisation led to the formation of the Aegean/Anatolia
97 microplate (highlighted by the GPS velocity field in Fig 1). The connection from the NAF to the
98 subduction zone (near Kefhalonia) marked diffuse Anatolia/Aegean plate boundary, also called the
99 Central Hellenic Shear zone (CHSZ – Fig. 1- McClusky et al., 2000; Goldsworthy et al., 2002;
100 Papanikolaou & Royden, 2007; Royden & Papanikolaou, 2011). It is characterized by major strike-slip
101 zones to the North and South (NAF, Kefhalonia) and major E-striking normal faults in the centre
102 (Corinth and Evvia rift – Fig. 1). The Corinth and Evvia rifts have been proposed to have opened at the
103 tip of the propagating NAF during the Plio-Quaternary (Armijo et al., 1996; Flerit et al., 2004). Note
104 that several NE-striking dextral strike-slip systems are also identified from seismological and geodetic

105 data inside the Aegean domain, with assumed Plio-Quaternary activity (bolded lines in Fig. 1 -
106 Sakellariou & Tsampouraki-Kraounaki, 2019).

107 Several observations, however, question this classical view of Aegean tectonics, suggesting active
108 strike-slip faulting also during middle Miocene times. First, the extrusion of Anatolia could have started
109 earlier during the middle/early Miocene as recently suggested by syn-tectonics calcite dating of the
110 NAF fault plane (Nuriel et al., 2019). At this time, extrusion was accommodated in a broader
111 deformation zone called the North Anatolian Shear Zone (Şengör et al., 2005). Second, the presence of
112 syn-kinematic dextral structures in middle Miocene plutons in the Cyclades suggest middle Miocene
113 activity of at least some NE-striking dextral strike-slip faults (Kokkalas, 2001; Koukouvelas and
114 Kokkalas, 2003; Kokkalas and Aydin, 2013). Note, however, that these middle Miocene plutons are
115 proposed to be potentially associated with detachment faulting or extensional shear zones (van
116 Hinsbergen and Schmid, 2012; Rabillard et al., 2015; Menant et al., 2016; Malandri et al., 2017;
117 Bessiere et al., 2018). The Myrthes-Ikaria Fault (also called the mid-Cycladic lineament – Fig. 1,
118 Walcott & White, 1998) is moreover proposed to be a major dextral strike-slip fault during the middle
119 Miocene. This fault may have accommodated Miocene block rotation in the Cyclades, as suggested by
120 the differences in the lineation trends between the North-West Cyclades and the Central Cyclades
121 (Philippon et al., 2012; Brun et al., 2016).

122 In order to provide new constraints on potential middle Miocene activity of NE-striking strike-slip
123 faults, Central Greece (including the Attica and Evvia regions) is a key place for the three following
124 main reasons. First, the majority of NE-striking faults of the Aegean domain are described offshore
125 (Fig. 1, Sakellariou and Tsampouraki-Kraounaki, 2019). The Pelagonian fault in Evvia (Central Greece,
126 Fig. 1), is one of the rare NE-striking structures cropping out onshore over a long horizontal distance.
127 This fault is a first order structure since it separates Pelagonia-derived rocks from Adria/Pindos
128 (structurally below Pelagonia)-derived rocks (Fig. 1). However, its kinematics is still discussed: normal
129 slip (Papanikolaou and Royden, 2007; Diamantopoulos et al., 2009) or dextral strike slip (Kokkalas,
130 2001; Xypolias et al., 2003). The age of its activity is also debated, as it is not clear if it has been active
131 only during the Plio-Quaternary or also during the middle Miocene (Kokkalas, 2001; Xypolias et al.,
132 2003; Bradley, 2012; Sakellariou et al., 2013). Second, Miocene extensional tectonics activity in the
133 Cyclades has been widely studied, with the existence of several major detachment systems (Gautier et
134 al., 1993; Jolivet et al., 2010b; Iglseider et al., 2011; Scheffer et al., 2016), while Miocene tectonics of
135 Central Greece is less constrained. The presence of strike-slip deformation together with NW- striking
136 high-angle normal faulting in Central Greece is proposed to be active since the middle Miocene inside
137 the Central Hellenic shear Zone (Fig. 1, Papanikolaou & Royden, 2007; Royden & Papanikolaou,
138 2011). Miocene deformation is also well-marked in the area through numerous middle Miocene basins
139 whose tectonics context of deposition remains to be characterized (Fig. 1, Bornovas and Rondogianni-
140 Tsiambaou, 1983). Third, low-temperature thermochronology ages provide an important constraint on
141 the deformation history of rocks during their last stage of exhumation in the upper crust. The Cyclades

142 have been extensively studied from this point of view with a clear middle to late Miocene cluster in age
143 (Hejl et al., 2002, 2008; Ring et al., 2003, 2007; Brichau et al., 2006, 2008; Seward et al., 2009; Berger
144 et al., 2013; Soukis and Stockli, 2013; Seman, 2016; Grasemann et al., 2018; Schneider et al., 2018)
145 highlighting important exhumation/extensional events at that time, related to detachment faulting
146 (Brichau et al., 2008; Jolivet et al., 2010a; Krohe et al., 2010; Iglseider et al., 2011; Grasemann et al.,
147 2018) and/or the coeval activity of high-angle normal faulting and strike-slip faulting during block
148 rotation (Philippon et al., 2012; Brun et al., 2016). In contrast to the Cyclades, the absence of low
149 temperature data in Central Greece (Fig. 1) obscures the timing and tectonics context of its exhumation
150 and a comparison with the Cyclades.

151 The objective of this study is to provide new structural and geochronological constraints in Central
152 Greece in order to characterize the role of both normal faults and NE-striking dextral faults (Pelagonian
153 Fault, Fig. 1) during the formation of two middle Miocene basins inside the island of Evvia and Attica
154 (Fig. 1). Furthermore, new low-temperature apatite fission-track (AFT) data acquired from the
155 Pelagonian rocks will allow a quantification of their exhumation history and hence a possible
156 comparison to the Cyclades.

157

158 **2. Geological setting**

159

160 Central Greece is formed by the stacking of Pelagonia-derived rocks on top of Adria-derived rocks,
161 separated by Pindos and Parnassos flysch and/or ophiolites (remnants of the Pindos ocean/deep basin -
162 Figs 1 and 2 - Papanikolaou, 2013). Pelagonian rocks mainly crop out in the north-west of Attica and
163 in the island of Evvia while Adria (some fragments of Pindos ophiolites) rocks are exposed in Western
164 Central Greece, in the South of Evvia and in all the Cyclades (Figures 1 and 2). The Pelagonian Fault
165 (PF - also called South Evvia North Attica fault, Bradley, 2012 - orange line in Fig. 2) limits the
166 Pelagonian and Adria/Pindos terranes in both Evvia and Attica (Xypolias et al., 2003).

167 Pelagonia is composed of two main units from bottom to top: 1/ Crystalline basement composed of a
168 para- and orthogneiss with Cambrian ages (Yarwood et al; 1976, orange in Fig. 2); 2/ (Meta)-
169 Sedimentary cover (pink, Fig. 2) with Permian metasediments and metavolcanics, Triassic to Jurassic
170 marbles, and limestone (Doutsos et al., 1993; Ross & Zimmerman, 1996). These units are thrust on
171 top of the Mesozoic to Lower Tertiary Beotian and Parnassos Flysch (Faupl et al., 2007; Nirta et al.,
172 2015). They have undergone greenschist facies metamorphism during the Early Cretaceous and locally
173 underlie ophiolites (dark green, Fig. 2).

174 The Pindos unit (between Pelagonia and Adria rocks) mainly crops out in western Central Greece and
175 is composed of Paleocene to Eocene flysch (Faupl et al., 2007).

176 Adria rocks are typical of continental rifted margin with contrasting deformation histories from west to
177 east (and from bottom to top): 1/ deformed sediment platform with a fold and thrust belt defining the
178 External Hellenides locally named Ionian, Plattenkalk, Phyllite and Gavrovo tripolitza units (Aubouin,

179 1959; Bonneau, 1984; Doutsos et al., 2006); and 2/ the Cyclades Blueschist Units which are composed
180 of Adria/Pindos derived rocks with HP/LT metamorphism (CBU, Bonneau, 1984). The CBU can be
181 subdivided in three main units (Bonneau, 1984; Trotet et al., 2001; Philippon et al., 2012): i/ basement
182 (gneiss and pelitic shales), ii/ metasedimentary cover (Triassic marbles and Mesozoic sediments), and
183 iii/ meta-ophiolitic rocks (serpentinite, meta-basalt, meta-chert, metagabbro) on top with well-preserved
184 HP-LT assemblages (e.g Syros, Philippon et al., 2013). The basement and sedimentary cover
185 correspond to the distal part of the Adria margin and the meta-ophiolite to the Pindos Ocean (Philippon
186 et al., 2012). The CBU is also exposed south of Evvia and Attica (called Evvia Blueschist Unit – EBU
187 - Katsikatsos et al., 1986; Katzir et al., 2000; Xypolias et al., 2003) and are thrust onto the autochthonous
188 Almyropotamos unit, which is the lateral equivalent of the external Hellenides (Gavrovo, Shaked et al.,
189 2000; Ring et al., 2007; Jolivet et al., 2013, Fig 2). The Almyropotamos unit consists of 1.5 km-thick
190 of Eocene-Oligocene metaflysch above 2 km-thick of Triassic-middle Eocene marbles interspersed with
191 shales.

192 Numerous Neogene basins cover this Aegean domain, with the majority being Pliocene-Quaternary in
193 age. They are also coeval with plate re-organisation and the formation of the North Anatolian Fault and
194 the Corinth and Evvia rift systems (see §Introduction and Figure 2 in Brun et al., 2016; see also Mascle
195 and Martin, 1990). We will focus our study on middle Miocene basins (Figs. 1 and 2), cropping out in
196 Central Greece. They are mainly filled with lacustrine and alluvial sediments (limestones and
197 conglomerates) and dated at around 14 Ma through K-Ar ages from syn-sedimentary volcanism
198 (Oxylithos unit in Kymi Basin in Evvia, Katsikatsos et al., 1981; Pe-Piper and Piper, 1994; Bradley,
199 2012). In the CBU, in the Peloponnese and in Crete, Miocene extensional tectonics is supposed to be
200 mainly controlled by low-angle normal faults (detachments). In particular, three major detachment
201 systems have been described in South Attica/Cyclades: the North Cycladic Detachment, the West
202 Cycladic Detachment (Lavriion detachment in Attica) and the Naxos-Paros/Central Cycladic
203 Detachment (Gautier et al., 1993; Jolivet et al., 2010a; Iglseeder et al., 2011; Scheffer et al., 2016;
204 Coleman et al., 2019). The Cretan detachment is mapped in Crete (Ring et al., 2001), while the Corinth-
205 Patras detachment has been described (Sorel, 2000) and debated (Bell et al., 2009) north of the
206 Peloponnese. Contrastingly, the Neogene basins (middle Miocene and Plio-Quaternary) in Central
207 Greece are proposed to be controlled by high-angle faults (Papanikolaou & Royden, 2007; Royden &
208 Papanikolaou, 2011). Plio-Quaternary basins are controlled by E-striking high-angle faults, defining the
209 major rift shoulders in Evvia and Corinth (Moretti et al., 2003; Bell et al., 2009). NW-striking high-
210 angle normal faults (Figs. 1 and 2), observed throughout Central Greece and the Peloponnese, are
211 proposed to control the middle Miocene basins deposition by reactivation in extension of former thrust
212 faults (e.g. Pindos/Adria limits or Pelagonia/Pindos limit, Fig. 1 and 2; Papanikolaou and Royden,
213 2007). These high-angle faults are seismically active today with dip-slip normal (E-striking faults) and
214 oblique sinistral and normal (NW-striking faults) kinematics (Roberts and Jackson, 1991; Kiratzi and
215 Louvari, 2003; Papanikolaou and Royden, 2007; Ganas et al., 2016). middle Miocene basins in Evvia

216 and Attica are also observed close to the NE-striking Pelagonian Fault (Figs. 1 and 2), which is initially
217 a thrust formed during subduction nappe stacking, separating Adria and Pelagonia (Papanikolaou,
218 2013). The age of the activity of the Pelagonian Fault is controversial, with a potential middle Miocene
219 age (Kokkalas, 2001; Xypolias et al., 2003). The Pelagonian Fault was characterized as a normal fault
220 because of differential exhumation in the footwall (CBU) and hangingwall (Pelagonia) (Shaked et al.,
221 2000; Papanikolaou and Royden, 2007; Diamantopoulos et al., 2009) or even as an extensional transfer
222 fault (Bradley, 2012).

223 Our objective is to constrain the tectonics history of Central Greece (Evvia and Attica) from the middle
224 Miocene to the present. To achieve our purpose, we will:

225 1/ Constrain the potential strike-slip activity of the Pelagonian Fault during middle Miocene times and
226 its relation with middle Miocene basin deposition. To this end, we study the tectonics context of two
227 middle Miocene basins: Limni (North Evvia) and Kymi (South Evvia) basins (Fig. 2). The Kymi basin
228 was chosen for its proximity with the Pelagonian Fault and it will be compared with the Limni basin,
229 which has no NE-striking structures. In particular, we aim to constrain the link between the activity of
230 NW-striking high-angle normal faults and NE-striking strike-slip faults in middle Miocene times.

231 2/ Characterize the link between NW-striking and E-striking normal faults to constrain the role of
232 middle Miocene inherited structures in controlling Plio-Quaternary faulting.

233 3/ Acquire new Apatite Fission Track data (AFT) to constrain the exhumation history of Central Greece
234 and its relationship to faults activity. This work will also provide the first AFT dataset in this region
235 (Fig. 1).

236

237 **3. Structural data**

238

239 **3.1. The Limni basin and NW-striking normal faults**

240 The northern middle Miocene Limni basin is located in the central part of northern Evvia (Fig. 3) and
241 contains lacustrine limestones, conglomerates and shales deposited on different units of Pelagonia: the
242 basement (gneiss and Permo-Carboniferous sediment) in the southern rim, Triassic-Jurassic
243 marble/schists and ophiolites to the north and east (see geological setting and Fig. 3).

244 We conducted a structural study with around 125 bedding measurements in the basin (stereonet of
245 basin's sediment beddings in Fig. 3B) and 83 faults measurements in the Pelagonian bedrock and
246 Miocene basin fill (stereonets of total faults shown in Figure 3B).

247 The structural map in Figure 3 shows the major faults inferred from our field study. Two main strike
248 directions are observed: NW-SE and E-W (map and stereonets of Fig. 3). Note that minor NE-striking
249 faults with horizontal slickenlines suggesting strike-slip motion and N-S faults are observed (location
250 III, Fig. 3A). At map scale, the basin is controlled in its southern rim by a major NW-striking high-
251 angle normal fault (fault 1, Fig. 3A), locally defining a NW-striking faulted zone in highly deformed

252 Pelagonian rocks (stereonet in location I, Fig. 3B and right picture in Fig. 3D). Local observations of
253 NW-striking normal faults with slickenlines show two families of slickenlines, one with dip slip and
254 one with slightly oblique slip (location II, Fig. 3A, stereonet in location II, Fig. 3B and left picture, Fig.
255 3D). Local observation on a fault plane with the two slickenlines suggest first a dip slip activity on
256 NW-striking normal fault and a more recent oblique slip on the same fault. The present-day seismic
257 activity shows consistently oblique sinistral on NW-striking faults (Roberts and Jackson, 1991;
258 Papanikolaou and Royden, 2007; Ganas et al., 2016). On these bases, we will define therefore two fault
259 families: NW-striking with dip slip (supposed to be active in middle Miocene, see below) and NW-
260 striking with oblique slip (supposed to be active in Plio-Quaternary as suggested by the present-day
261 seismic activity – Ganas et al., 2016)

262 A NE-SW cross-section (orthogonal to the major normal fault 1, Fig. 3C) shows the relationship
263 between NW-striking faults and the basin bedding. It highlights a major offset of the Pelagonian
264 basement in the footwall by the NW-striking fault 1 and the Pelagonian marble and schist, covered by
265 middle Miocene sediments in the hangingwall. This observation implies a minimum vertical offset of
266 the thickness of the marble/schists and of the ophiolite unit of the Pelagonian which is at least 1 to 2 km
267 thick (Xypolias et al., 2003). In the basin, minor NW-striking normal faults are observed with limited
268 offset in the Pelagonian bedrock (faults 2, 3 and 4), as shown in cross-section Fig. 3C. Although the
269 Limni basin is bordered and internally affected by NW-striking normal faults, the dip of the bedding is
270 relatively flat (stereonet of basin's sediment beddings, Fig. 3B), with a mean dip value of around 30°
271 and a mean strike of NW-SE. Furthermore, our bedding measurements suggest that the basin thickness
272 slightly increases in the hangingwall of major faults (like fault 1, cross-section in Fig. 3C). This
273 observation suggests that NW-striking faults are synchronous with basin deposition.

274 These NW-striking normal faults strongly affect the Evvia and Attica areas (Fig. 2 and 3) by controlling
275 the mean strike of the Evvia Gulf. Locally NW-striking normal faults are cross-cut by E-striking normal
276 faults (location I, Fig. 3A, stereonet in location I, Fig. 3B and right picture, Fig. 3D). At map scale, this
277 observation is also validated. In the Northern part of Evvia, near Loutra Edipsou, the coastline evolves
278 from a NW-SE strike in the South to an E-W strike to the North showing the interplay (observed at
279 small scale at locations IV and V, Fig. 3A and stereonets in location IV and V, Fig. 3B) between NW-
280 striking normal faults and E-striking normal faults.

281

282 **3.2. Loutra Ypatis: E-striking and NW-striking normal faults**

283 The western termination of the Evvia Gulf also shows remarkable interactions between NW- and E-
284 striking fault structures.

285 The active Kamena Vourla fault (location I, Fig. 4A, stereonet in location I in Fig. 4B and pictures a-b
286 in Fig. 4C - Cundy et al., 2010; Walker et al., 2010), defining the southern rim of the Evvia Gulf and
287 visible from the Athena-Thessaloniki highway, shows a large fault plane with slickenlines (pictures a-
288 b in Fig. 4C). Our data suggest two dominant strikes: E-W and NW-SE. NW-striking faults evolve

289 locally to an E-W strike with the same slickenlines (location I in Fig. 4A and stereonet in location I,
 290 Fig. 4B). Similar features have been observed south of the Limni basin (Loutra Edispou – locations IV
 291 and V, Fig. 3A, and see details in the above section 3.1). At map scale, the Kamena Vourla fault system
 292 is part of an E-W en-échelon-system inside a NW-striking zone, explaining these two strikes.

293 This en-échelon system is found at larger scale, with five main E-striking fault segments from East to
 294 West: Arkitsa (already characterized with high resolution data by Jackson and McKenzie, 1999;
 295 Kokkalas et al., 2007), Kamena Vourla (location I, Fig. 4A), Thermopyles (location III, Fig 4A and
 296 stereonet in location III, Fig. 4B), Loutra Ypatis (location V, Fig. 4A, stereonet in location V, Fig. 4B
 297 and picture c, Fig 4C) and Lefkada. These E-striking fault segments are connected by NW-striking
 298 normal faults mapped in location II and IV (stereonets in locations II and IV in Fig. 4B) and NW-
 299 striking fault in west of Arkitsa fault and Kamena Vourla fault (location I, Fig. 4A). This en-échelon
 300 system defines the southern rim of the Evvia Gulf which is therefore, a NW-SE oblique rift with active
 301 E-striking normal faults.

302

303 **3.3. Normal faults and stress tensors in Limni and Loutra Ypati areas**

304

305 **3.3.a. Inversion method**

306 We invert our measured fault and slip data for paleostress . The inversion seeks a stress tensor that
 307 yields a shear stress direction on each fault plane as close as possible to the measured slip direction
 308 (Wallace, 1951; Bott, 1959; Angelier, 1984). We use the Fsa software (Burg et al., 2005; Célérier, 2020)
 309 that implements the random search method proposed by Etchecopar et al. (1981). This method allows
 310 inverting either the whole dataset in the case of monophasic data, or only a fraction of the dataset in the
 311 case of polyphasic data. It yields the principal stress directions s_1, s_2, s_3 , and stress tensor aspect ratio r_0
 312 $= (\sigma_1 - \sigma_2) / (\sigma_1 - \sigma_3)$, where $\sigma_1 \geq \sigma_2 \geq \sigma_3$ are the principal stress magnitudes corresponding to the
 313 directions s_1, s_2, s_3 . We use the quality criterion proposed by Heuberger et al. (2010) to distinguish
 314 robust solutions from possible statistical artifacts. It is based on a comparison between the total number
 315 of data in the data set, N_{total} , the number of data with a rake misfit lower than 15° , N_{exp15} , and the
 316 number of data N_{0exp15} that could be obtained below the same misfit threshold by inverting a random
 317 dataset of the same size N_{total} . The result of this comparison is summarized by an integer quality index,
 318 $InvQual$, that varies from -1, for solutions that could be artifacts, to 2 for robust estimates. Because each
 319 data set is partly heterogeneous, each inversion is carried out in two steps to cancel the influence of
 320 outliers on the solution. In a first step, all data are considered, and the proportion of data with acceptable
 321 angular misfit (below 15° or 30° , depending on cases) is determined. In a second step, the inversion is
 322 required to account only for that proportion of data. To facilitate the discussion of the results, we will
 323 call a fault slip datum compatible or incompatible with a stress tensor when the angular misfit between
 324 its slip vector and the predicted shear stress direction is less than 15° or more than 30° respectively. We

325 will also distinguish the terminology for tectonics regimes, compressional, wrench, and extensional,
 326 following C el erier (1995), from that of fault types, reverse, strike-slip, and normal.

327

328 **3.3.b. Dataset**

329 Our structural data show that Limni and Loutra Ypatis areas are controlled by three families of faults:
 330 family 1/ E-striking normal faults, family 2/ NW-striking normal fault with oblique-slip (strike-slip
 331 faults), and family 3/ NW-striking normal faults (e.g. with dip slip). Families 2 and 3 having similar
 332 fault plane orientations with markedly different slip orientations suggests that they belong to distinct
 333 tectonics phases, which is further supported by occasional slickensline record of these different slips on
 334 the same fault. Families (1) and (2) are seismically active today (Roberts and Jackson, 1991;
 335 Papanikolaou and Royden, 2007; Ganas et al., 2016), Our structural data show that NW-striking faults
 336 (with dip slip, Family 3) are synchronous with middle Miocene basin deposition. Family 3 was therefore
 337 active in middle Miocene, at a different period of time compare with families 1 and 2. We combined
 338 families 1 and 2 and kept the family 3 separated for the inversions, to obtain, respectively, a Plio-
 339 Quaternary stress tensor and a middle Miocene stress tensor.

340

341 **3.3.c. Results**

342 The resulting stress tensors are labeled with a subscript that indicates the family combination they are
 343 calculated from: T_3 is computed from family 3, while T_{12} is computed from the combination of families
 344 1 and 2. They are shown in stereographic projection with the data they are computed from in Fig. 5.
 345 Their parameters are listed in supplementary material Table ST1 while the inversion parameters and
 346 quality are documented in Table ST2. Detailed misfit distributions and Mohr's circles are shown in
 347 Appendix (Fig. S1 and S2).

348 The combination of the two first families yields 40 faults and slip data and reduced stress tensor T_{12}
 349 with nearly vertical maximum principal stress s_1 , thus in the extensional regime (Fig. 5A and
 350 supplementary materials Tables ST1 and ST2). The minimum principal stress, s_3 , is horizontal and
 351 oriented North-South. However, the aspect ratio, $r_0 = 0.92$, places the regime close to radial extension
 352 and thus suggests that the orientations of the horizontal principal stress are not highly significant. This
 353 solution yields an average angular error of 8.1° for 75% of the data, and accounts for 25 faults with rake
 354 misfit below 15° ($N_{exp15} = 25$), which ensures a high statistical significance with $InvQual = 2$
 355 (supplementary material Table ST2).

356 The third family contains 15 data and yields stress tensor T_3 also in the extensional tectonics regime
 357 with a horizontal minimum principal stress, s_3 , oriented NE-SW (Fig. 5B). The aspect ratio, $r_0 = 0.8$,
 358 places the regime into a typical extension, further away from radial extension than T_{12} . The average
 359 angular error is 7.7° for 100% of the data, and 12 faults have rake misfit below 15° ($N_{exp15} = 12$), but
 360 the small number of data results in a lower quality solution with $InvQual = 1$ (supplementary material
 361 Table ST2).

362 This inversion therefore suggests:

363 1/ Almost radial extension during Plio-Quaternary (tensor T_{12} with s_3 orientated N-S) associated with
364 dip-slip motion on new-formed E-striking normal faults and oblique sinistral and normal motion on pre-
365 existing NW-striking normal faults

366 2/ NE-SW extension along NW-striking normal faults during middle Miocene times

367

368 **3.4. The Kymi basin: NW-striking normal faults and NE-striking dextral faults.**

369 Our structural analysis on the middle Miocene Kymi basin (location on Figure 2 and local map in Fig.
370 6A) allows the identification of the key faults controlling the sediment deposition. From bottom
371 upwards, the basin contains lacustrine and conglomerate deposits (Bradley, 2012). Oxyolithos volcanics
372 intruded the basin during sediment deposition at 14 Ma (Fig. 6A, Pe-Piper & Piper, 1994) allowing
373 relative dating of the basin to be middle Miocene. The basement of the basin is composed of Pelagonian
374 rocks (Paleozoic, Triassic-Jurassic marble and schists and Cretaceous sediments), forming large scale
375 open folds: NE-SW Amarynthos antiform and synform below the basin (Fig. 6A, Xypolias et al., 2003;
376 Bradley, 2012). Similar folds are observed in the Adria unit (EBU, Almyropotamos antiform, Kokkalas,
377 2001; Xypolias et al., 2003). At map scale, the Pelagonian Fault separates the Pelagonian (to the North)
378 from the EBU (to the South) and marks the southern limit of the Kymi basin (orange line in Fig. 6). We
379 extended our analysis to the Nea-Palatia middle Miocene basin in Central Greece (Fig. 6A) in order to
380 constrain the southern continuity of the Pelagonian Fault. Our study yielded 185 fault measurements
381 (Fig. 6B stereonet of total faults), mainly outside of the basin, and 354 bedding measurements (Fig. 6B
382 stereonet with 44 basin's sediment beddings).

383 Two main fault directions with map-scale fault trace exposure were observed: NW-striking normal
384 faults and NE-striking sub-vertical strike-slip faults parallel to the map scale strike of the Pelagonian
385 Fault (stereonets in Fig. 6B). Minor E- and N- striking faults are observed, with no clear map-scale fault
386 trace exposure (stereonets, Fig. 6B).

387 In the Kymi basin, NW-striking normal faults are found in the south-western part of the basin marking
388 the contact between lacustrine sediments and Pelagonian rocks (location I in Fig. 6A and stereonet in
389 location I, Fig. 6B). Similarly, the northern rim of the Kymi basin is mainly controlled by NW-striking
390 normal faults (as already discussed in Bradley, 2012), a feature that is similar to our findings in the
391 Limni basin. Associated with these normal faults, we found NE-striking vertical faults, with sub-
392 horizontal slickenlines and a dextral shear sense, defining a NE-striking corridor that limits the Kymi
393 basin (location II, Fig. 6A and stereonet in location II, Fig. 6B). The southern limit of the Kymi basin
394 is mainly controlled by these NE-striking faults (e.g. Pelagonian Fault, PF).

395 The novelty of our data is to provide numerous fault data with vertical plane and horizontal slickenlines
396 along the Pelagonian Fault (locations III-IV, Fig. 6A, stereonets in locations III-IV, Fig. 6B and picture
397 in Fig. 6C) that will be used for the stress inversion (see below). At location III, the Pelagonian marbles
398 are strongly deformed, forming either large breccias or defining a new sub-vertical NE-striking

399 schistosity at high-angle to the regional schistosity of Pelagonian schists (picture in Fig. 6D). Even in
 400 this strongly faulted zone, NW- striking normal faults are always observed, with no cross-cutting
 401 relationships, suggesting a possible coeval activity of strike-slip and normal faults (Fig. 6B, stereonet
 402 in locations III-IV and V). At map scale, the Pelagonian Fault defines the southern rim of the basin
 403 (cross-section Fig. 6E) indicating activity of the fault after or during the deposition of the Kymi basin.
 404 In addition, sub-horizontal bedding of the basin, even close to the PF, suggests that the basin is not
 405 deformed by the Pelagonian Fault (stereonet of basin's sediment beddings in Fig. 6B and cross-section,
 406 in Fig. 6E), indicating basin deposition during the PF activity (as already suggested by Kokkalas, 2001;
 407 Xypolias et al., 2003).

408 Similar conclusions can be drawn in the Nea-Palatia basin in Attica. The southern/eastern rim of the
 409 middle Miocene basin is marked at map scale by NE-striking dextral strike-slip faults (locations VI in
 410 Fig. 6A and stereonet in location VI in Fig. 6B). Note again the existence of NW-striking normal faults
 411 inside or close to NE-striking strike-slip faults, suggesting a potential coeval activity of normal faults
 412 and strike-slip fault (location VII in Fig. 6A and stereonet on location VII in Fig. 6B). This dextral fault
 413 zone is not directly continuous from the Pelagonian Fault in Evvia, suggesting two branches: one
 414 northern branch in Evvia, one southern branch in Central Greece. The northern branch (the Pelagonian
 415 Fault in Evvia) most probably ends inside the Evvia Gulf and leads to limited deformation in Central
 416 Greece (northern location VI in Fig. 6A). These two branches define a strike-slip corridor at regional
 417 scale (Fig 6A).

418

419 **3.5. Stress tensor for the NE-striking strike-slip faults.**

420 The 25 NE-striking strike-slip faults from the Kimi area define our 4th family of faults. Inverting it
 421 yields a new stress tensor T_4 , a good quality solution (Table ST2), with a nearly vertical intermediate
 422 principal stress, s_2 , thus in the wrench tectonics regime, and with a horizontal minimum principal stress,
 423 s_3 , oriented North-South (Fig. 7 and supplementary materials S3 and Table ST1). An average angular
 424 error of 4.5° for 76% of the data and 19 faults with rake misfit below 15° ($N_{exp15} = 19$) result in a good
 425 quality: $InvQual = 2$ (supplementary material Table ST2). This stress tensor is different from the stress
 426 tensors inferred from E-striking normal faults with NW-SE oblique sinistral faults (T_{12}) and NW-
 427 striking normal faults with dip-slip (T_3), due to the differences on the vertical principal stress axis: T_{12}
 428 and T_3 are in extensional regime (s_1 vertical) while T_4 is in wrench regime (s_2 vertical). In the discussion
 429 section, we will discuss the compatibilities between T_3 and T_4 , since our field data suggest coeval
 430 activities of NE-SW strike-slip and NW-SE normal faults with dip slip.

431 For T_4 stress tensor, the maximum principal stress direction s_1 is horizontal and orientated E-W (Fig.
 432 7). Large scale folds in the Pelagonian rocks and the EBU, orientated N-S, are consistent thus consistent
 433 with this inferred shortening direction and hence with dextral strike-slip activity of the Pelagonian Fault
 434 (Fig. 6A, Fig. 7C). Moreover, the parallelisation of the fold axes evolving from N-S to NE-SW towards

435 the Pelagonian Fault supports coeval PF activity and folding (Xypolias et al., 2003). Kymi basin
436 deposits in a NE-SW oriented syncline, suggesting deposition during strike-slip activity (Fig. 6E).

437

438 **4. Low-temperature thermochronology data**

439

440 **4.1. Method**

441 We conducted Apatite Fission Track (AFT) analysis to constrain the exhumation history of the
442 Pelagonian rocks in Central Greece, since no data are presently available in this region (Fig. 1). Samples
443 were selected along a transect perpendicular to the Pelagonian Fault to characterize its impact on rock
444 exhumation (samples location on Fig. 2 and Figs. 3,4,6). This new dataset, together with previous zircon
445 fission track (ZFT), AFT and (U-Th)/He ages from Central Greece, will permit a comparison to
446 published ages in the Cyclades that cluster around 10-12Ma, potentially revealing the role of the
447 Pelagonian Fault on regional exhumation (Fig. 1, and see our Introduction and Geological setting for
448 further details).

449 The AFT thermochronology data provide thermal information within a 60°C to 120°C temperature
450 range, allowing us to describe the exhumation or burial of rocks within the upper 2 to 5 km of the crust
451 (Gleadow & Duddy, 1981). AFT data will therefore be used to identify the last stage of exhumation in
452 the upper crust and the potential role of the faults. Some samples were chosen close to the identified
453 NW-striking faults, to provide further constraints on their age.

454 Six key-samples were selected (location Fig. 2): CG03 (Pelagonian schists close to Pelagonian Fault),
455 CG08 (metamorphic Pelagonian schists), CG11 and CG13 (Pelagonian metamorphic basement), CG14
456 and CG16 (Pindos Flysch). CG11, CG13, CG16 and CG14 are located on the footwall of NW-striking
457 normal faults.

458 The apatite samples were mounted on glass slides using epoxy glue and polished. Samples were etched
459 in 6.5% HNO₃ (1.6 M) for 45 seconds at 20°C to reveal the spontaneous fission tracks (Seward et al.,
460 2000), before being irradiated with a neutron fluence rate of 1.0×10^{16} neutrons/cm² (Oregon State
461 University, Oregon, U.S.A.). The micas used as external detector were etched in 40% HF for 40 minutes
462 at 20°C in order to reveal the induced fission tracks. The ages were calculated following the method
463 recommended by the Fission Track Working Group of the I.U.G.S. Subcommittee on Geochronology
464 (Hurford, 1990) using the zeta calibration method (Hurford & Green, 1982). CN5 glass was used as a
465 dosimeter. Ages were calculated using an overall weighted mean zeta value of 313.2 ± 11.96 a cm²,
466 obtained on both Durango (McDowell et al., 2005) and Mount Dromedary apatite standards (Green,
467 1985; Tagami, 1987). Samples were analyzed at the University of Rennes 1 – Observatoire des Sciences
468 de l'Univers de Rennes using the Autoscan© software (on manual mode) on a Zeiss M1 microscope,
469 with a magnification of 1250 under dry objectives. All ages are central ages and errors are quoted at 2σ
470 (e.g. Galbraith & Laslett, 1993 ; Galbraith, 2005). The Dpar kinetic parameter was measured on all
471 analysed crystals for each sample and corrected following the method of Sobel & Seward (2010). Due

472 to the generally poor quality of the apatite crystals, not enough confined track lengths could be measured
473 in each sample to allow robust thermal modelling. Data are reported in Table 1.

474

475 **4.2. Data**

476 Samples selected for AFT analysis are from both metamorphic and detrital rocks.

477

478 **4.2.a. Metamorphic samples**

479 Sample CG03 comes from the shales of the Triassic-Jurassic marble-schist unit included in the
480 Pelagonian Fault. Eleven grains give a central age of 38.8 ± 6.3 Ma. Sample CG08 comes from the same
481 unit further north and has a central age of 30.9 ± 4.7 Ma based on 22 crystals (Fig. 8A). Considering
482 the high $P(\chi^2)$ value ($\sim 100\%$), the individual apatite ages seem to be regrouped in one main age
483 population ranging from Palaeocene to Oligocene. Three early/middle Miocene ages mark younger ages
484 of this group in CG08 (Fig. 8B). The chlorite schists sample CG11 in the Pelagonian Paleozoic
485 basement yields a central age of 19.3 ± 2.0 Ma based on 19 analysed crystals. As suggested by the
486 relatively low $P(\chi^2)$ of 38%, this sample shows two distinct age groups, one Oligocene the other early
487 to middle Miocene (grey and red arrow Fig. 8C). Sample CG13 is a gneiss from the Pelagonian
488 basement, comparable with CG11 but with potentially higher metamorphic grade. Only seven apatite
489 crystals could be dated. The individual ages range between 25 and 45 Ma with a central age of 30.8
490 ± 7.2 Ma (Fig. 8D).

491

492 **4.2.b. Detrital apatite samples**

493 These samples provided more apatite crystals compare to the metamorphic samples. CG14 was
494 collected from the Pindos Flysch. The analysis of 50 crystals provided a central age of 36.4 ± 3.1 Ma.
495 The individual ages are largely scattered between 90 and 12 Ma. The sample displays three age groups:
496 1/ an older group corresponding to Palaeocene-early Eocene times, 2/ a Mid-Eocene to Oligocene group
497 and 3/ a younger early Miocene group (Fig. 8E). Sample CG16, also collected in the Pindos Flysch
498 gives a younger central age of 30.7 ± 4.7 Ma based on 23 crystals. Individual ages are scattered between
499 139 and 10Ma (Fig. 8F). However, two groups are distinguished with a respective age population
500 ranging from Cretaceous to early Eocene and Oligocene to middle Miocene. The second group is mainly
501 composed of Miocene ages.

502

503 **4.3. AFT data interpretation**

504 Samples CG03 and CG08 from the lower Mesozoic series have clearly been reset after the sediment
505 deposition but the large spread in individual ages associated with late Eocene – Oligocene central ages
506 suggests slow exhumation initiated during that period (Fig. 8). Sample CG11, collected in the same unit
507 as CG13, also displays few Oligocene ages but the early Miocene central age suggests either a later

508 exhumation or an exhumation from a deeper level. The second hypothesis would be consistent with the
509 stratigraphic position of sample CG11 situated below sample CG13. The stratigraphic age of the
510 sediments that formed samples CG14 and CG16 is assumed to be between 70 and 45 Ma (Faupl et al.,
511 1998, 2007).

512 The occurrence of individual ages much older than the deposition age (especially in sample CG16)
513 suggests, at most, partial post-depositional resetting within the apatite partial annealing zone (Fig. 8).
514 The sediments were therefore buried to a depth of less than 4km, allowing sufficient annealing to
515 rejuvenate some of the apatite crystals, the degree of annealing probably depending on chemical
516 composition (Barbarand et al., 2003). The Oligocene central ages obtained for those two samples again
517 suggest exhumation during that period, implying a regional event.

518 The youngest age groups observed in samples CG11, CG14, CG16 and possibly CG08 could be
519 interpreted as a final exhumation phase dated at the minimum from the early Miocene (CG14) to middle
520 Miocene (CG08, CG11 and CG16, red arrow - Fig. 8).

521 Our AFT data show, in the majority of samples, an Oligocene exhumation event and a second early to
522 middle Miocene exhumation phase (arrows in Fig. 8 and Fig. 9). The associated large dispersion of the
523 AFT individual ages suggests a phase of slow exhumation of the Pelagonian rocks in Central Greece
524 during the Oligocene. The middle Miocene AFT ages recorded in our samples are strongly related to
525 NW-striking high-angle normal faults. The locations of samples CG11, CG16 and potentially CG14 in
526 the footwall of NW-striking normal faults (Fig. 9A), highlight local exhumation during a relatively fast
527 middle Miocene event (compared to the Oligocene phase). This feature suggests a middle Miocene
528 activity of the NW-striking normal faults, as already suggested by our structural analysis.

529

530 **5. Discussion**

531

532 **5.1. Differential amount of exhumation across the Pelagonian fault**

533 Our new AFT data allow, for the first time, a regional-scale comparison between the Cycladic unit and
534 the Pelagonian unit (Fig. 9A). In Central Greece, our AFT data show a clustering in age around the
535 Oligocene. Published AFT, zircon fission track (ZFT) and (U-Th)/He on zircon data in northern Greece
536 (Hejl et al., 1999, 2008; Most, 2003; Thomson et al., 2009; Vamvaka et al., 2010; Coutand et al., 2014;
537 Schenker et al., 2015) also presented numerous ages in the early-Miocene, Oligocene and older ages,
538 suggesting a regional exhumation event at minimum before 16Ma (Fig. 9B). The Cyclades also recorded
539 an Oligocene exhumation (with Ar/Ar ages, see synthesis of thermochronology in Philippon et al., 2012)
540 inducing a widespread exhumation throughout the Aegean domain at this time. However, in the
541 Cyclades, the low-temperature thermochronology ages (ZFT, AFT, U-Th/He on zircon and Apatite –
542 Hejl et al., 2002, 2008; Ring et al., 2003, 2007; Brichau et al., 2006, 2008; Seward et al., 2009; Berger
543 et al., 2013; Soukis and Stockli, 2013; Seman, 2016; Grasemann et al., 2018; Schneider et al., 2018) are
544 much younger and concentrated in the late/middle Miocene, suggesting faster exhumation during this

545 period (Fig. 9A and B). This Miocene cluster of low-temperature thermochronology ages marks the
546 large amount of extension/exhumation recorded in the Cyclades, as exemplified by the activity of
547 several low-angle normal fault/detachment systems (Avigad and Garfunkel, 1989; Gautier et al., 1993;
548 Tschegg and Grasemann, 2009; Jolivet et al., 2010b; Krohe et al., 2010; Iglseider et al., 2011; Grasemann
549 et al., 2012, 2018). In Central Greece, the young AFT ages are concentrated on samples close to some
550 high-angle normal faults (see our data and data from Coutand et al., 2014 in the Sporades), contrastingly
551 suggesting a limited amount of exhumation/extension during Miocene time. Furthermore, scattered
552 AFT ages between the Paleogene/Oligocene to late-Miocene could suggest slow exhumation of the
553 Pelagonian rocks or heterogenous amount of exhumation at regional scale. This highlights a major
554 difference in the amount of exhumation and hence of crustal extension between Central Greece and the
555 Cyclades during the Miocene. This feature is also exemplified at first order by the unroofing of the
556 Cycladic unit, structurally below Pelagonia (see nappe stack discussion in our introduction and in Fig.
557 1). We suggest that the Pelagonian strike-slip fault accommodates lateral differences in the amount of
558 extension during the Miocene. This is accompanied by a large amount of extension accommodated by
559 detachment faults in the Cyclades, and much lower amount of extension in Central Greece mainly
560 accommodated by high-angle normal faults (Figs. 2 and 9).

561

562 **5.2. Central Greece faulting activity and middle Miocene basins**

563 Our structural data show that in the middle Miocene, syn-tectonics basin sedimentation is coeval with
564 NW-striking normal faults and NE-striking dextral strike-slip activities (Fig. 2). Limni basin deposition
565 (North Evvia) is controlled by NW-striking normal faults (with dip slip motion). AFT data on samples
566 in the footwall of these normal faults show local middle Miocene ages, suggesting middle Miocene
567 cooling. Our structural data are consistent with the formation of the Limni basin during NE-SW
568 extension (Fig. 5) in Miocene time controlled by NW-striking normal faults, as already suggested by
569 Mettos et al. (1991), (1992). The Kymi basin deposition is mainly controlled by the dextral strike-slip
570 Pelagonian Fault corridor (Fig. 2), locally associated with NW-striking normal faults. Previous studies
571 have already suggested strike-slip activity along the Pelagonian Fault during the middle Miocene but in
572 a transpressive context (Kokkalas, 2001; Xypolias et al., 2003; Kokkalas et al., 2006). Our stress tensor
573 calculation on the Pelagonian fault implies an E-W direction of compression (Fig. 7) that is consistent
574 with compressional structures described previously (Kokkalas, 2001; Xypolias et al., 2003) but does
575 not require a transpressional context. The combination of our structural data from Limni and Kymi
576 basins suggests coeval middle Miocene activity of the NW-striking normal faults and the NE-striking
577 strike-slip faults, indicating instead a transtensive regime during Kymi basin deposition. At large scale,
578 E-W shortening is also highlighted by the presence of large open folds (i.e. Almyropotamos fold –
579 Evvia island, Penteli - North of Athens and Ymitos mountain – East of Athens, see map in Bradley,
580 2012) with the axis evolving from N-S to NE-SW close to the Pelagonian dextral strike-slip fault
581 (Kokkalas, 2001; Xypolias et al., 2003). In summary, our structural data show that the middle Miocene

582 tectonics of Central Greece is marked by the coeval activity of NE-striking dextral faults and NW-
583 striking normal faults, with spatial strain partitioning: NE-striking faults mainly inside the Pelagonian
584 fault strike-slip corridor, associated in its vicinity with N/NE-S/SW folds, and away from this corridor,
585 extension with NW-striking normal faults (Fig. 2). At regional scale, the existence of strike-slip activity
586 in middle Miocene times is also independently suggested by the presence of syn-kinematics structures
587 in middle Miocene plutons in the Cyclades (Walcott and White, 1998; Kokkalas and Aydin, 2013),
588 although their fault kinematics are still debated (van Hinsbergen and Schmid, 2012; Malandri et al.,
589 2017).

590 Our structural data show that the Plio-Quaternary is marked by E-striking normal faults mainly
591 developed inside pre-existing NW-striking faults. Kokkalas (2010) describes the consistently close link
592 between NW-striking and E-striking normal faults, with E-W relay zones inside major NW fault zones.
593 This interplay defines a complex fault zone growth and propagation, likely explaining the major fault
594 striking NW in Central Greece. This likely explains NW-striking oblique rift systems in Central Greece
595 (Evvia and Corinth, Fig 2) associated with E-striking normal faults. These tectonics structures control
596 Plio-Quaternary basin formation.

597

598 **5.3. Stress regimes in Mid Miocene and Plio Quaternary times.**

599 Stress tensor calculations show that the Plio-Quaternary N-S extension is associated with E-striking
600 normal faults and oblique reactivation of NW-striking normal faults (Fig. 5). These findings are
601 consistent with present-day seismic activity and focal mechanisms showing coeval E-striking normal
602 faulting, sinistral normal activity along these NW-striking faults (Kiritzi and Louvari, 2003; Ganas et
603 al., 2016), as well as N-S strain rate directions inferred from GPS data (Davies et al., 1997; Reilinger et
604 al., 2006; Hollenstein et al., 2008; Pérouse et al., 2012). Similar conclusions were proposed further
605 North, close to the Olympus Mount (e.g. Kozani normal fault – Schenker et al., 2015).

606 Because the present-day seismic activity shows also coeval NE-striking dextral strike-slip (e.g. North
607 Anatolian Fault to the North of the studied area) and E-striking normal faulting in Greece, (e.g. Corinth
608 and Evvia rifts), we tested the compatibility between our measured NE-striking dextral faults
609 (Pelagonian fault, family 4) and the combination of E-striking normal faults (family 1) and NW-striking
610 strike-slip faults (family 2) by inverting them together. The combination of these three families yielded
611 T_{124} stress tensor (supplementary materials Fig. S4, Table ST1) in the wrench tectonics regime (Fig. 10
612 and supplementary material Table ST2). Even though the solution quality is statistically good (Table
613 ST2), it comes into sight that, whereas it accounts for most data from family 4, it poorly accounts for
614 data from families 1 and 2 (supplementary material Fig. S7). It thus appears more like the result of
615 extracting a phase, similar to T_4 from a multiphase family, rather than a phase explaining all three
616 families 1, 2 and 4 together. The combination of family 4 with families and 1 and 2 thus fails to
617 demonstrate compatibility and rather highlights heterogeneity. The poor compatibility of family 4

618 (dextral strike-slip) with the combination of families 1 and 2 (normal and sinistral faults) is, in fact,
 619 consistent with the total absence of dextral strike-slip faults in Central Greece, a region only
 620 characterized by Plio-Quaternary extension (Corinth and Evvia rifts, Stefatos et al., 2002; Lykousis et
 621 al., 2007; Bell et al., 2009). This suggests a Plio-Quaternary strain partitioning with normal faulting in
 622 Central Greece and dextral strike-slip faulting in Northern Greece (North Anatolian Trough and North
 623 Anatolian Fault). This furthermore suggests the absence of a clear link between the NAF and
 624 Corinth/Evvia rift systems, at variance with Armijo et al. (1996).

625 Our structural observations suggest in contrast a coeval activity of NW-striking normal faults (family
 626 3) and NE-striking strike-slip faults (family 4) during middle Miocene. We thus tested the stress
 627 compatibility between these two families by inverting them together. This combination yields T_{34} stress
 628 tensor in the wrench tectonics regime with vertical s_2 and $r_0 = 0.14$, thus close to the transition with the
 629 extensional regime (Figs. 10A and 10B and supplementary material Table ST1). This solution accounts
 630 for most data of families 3 and 4 ($N_{exp15} = 27$, supplementary materials Table ST2; Fig S5) with a
 631 quality equivalent to that of T_4 , thus supporting compatibility between these two families. Therefore,
 632 T_{34} tensor suggests a wrench middle Miocene tectonics regime activating both normal and dextral faults
 633 (Figs. 10B and E).

634 Palaeomagnetic data support mean value of $\sim 30^\circ$ of rotation (Horner and Freeman, 1983; Kissel et al.,
 635 1986, 2003; Duermeijer, 2000; van Hinsbergen et al., 2005, 2006; Bradley et al., 2013) during Miocene
 636 times, with a rotation pole close to Scutari-Pec. NW-striking normal faults, formed before or during
 637 such rotation, were therefore rotated during Miocene times. In contrast, NE-striking dextral fault have
 638 undergone little if any rotation because they are sub-parallel to the small Eulerian circle. We, therefore,
 639 suggest that NE-striking faults accommodated the clockwise rotation, which is consistent with their
 640 dextral movement (inset of Fig. 11B). We, therefore, applied a 30° counter-clockwise vertical axis
 641 rotation to the NW-striking normal faults (family 3) to restore them in their Miocene original position
 642 (family 3r – after a backrotation of 30° , Fig. 10C). We then combined this restored family 3r (became
 643 E-striking normal faults) with the NE strike-slip faults (family 4) and inverted this combination. This
 644 yielded T_{3r4} in the wrench tectonics regime (Figs. 10D and E and supplementary material S6). This
 645 solution is similar to T_{34} , with a similar quality, also with a horizontal maximum principal stress
 646 direction, s_1 , that is now close to E-W (supplementary materials Table ST1 and ST2).

647

648 **5.4. Central Greece tectonics since Miocene times**

649 On these bases, we propose the following evolution of Central Greece tectonics since middle Miocene
 650 times. In the middle Miocene, the co-existence of NE-striking dextral strike-slip and E-striking normal
 651 faults (i.e. back-rotated present-day NW-striking faults – Fig. 11A) corresponds to a wrench tectonics
 652 regime with an almost N-S extension and E-W compression (T_{3r4} tensor – Fig. 11A). We propose that
 653 the E-W compression is related to westward extrusion of Anatolia that most probably started during the
 654 middle Miocene in a broad zone of deformation (North Anatolian Shear Zone, Şengör et al., 1979,

655 2005). Furthermore, the existence of calcite gouge in the NAF with middle Miocene ages supports this
656 hypothesis (Nuriel et al., 2019). This E-W compression is furthermore consistent with middle Miocene
657 transpressional structures affecting molasse basins and granitic intrusions (Kokkalas et al., 2006;
658 Kokkalas and Aydin, 2013). The extensional direction is orthogonal to the middle/late Miocene position
659 of the Hellenic trench, suggesting that extension was controlled by Aegean trench retreat (Papanikolaou
660 & Royden, 2007; Royden & Papanikolaou, 2011). The observed spatial distribution of deformation,
661 with strike-slip corridors localising shortening (with folds) and pure extensional structures away from
662 these corridors, may be controlled by tectonics inheritance, as the Pelagonian strike-slip corridor is
663 located in the main contact between Adria/Pindos and Pelagonia.

664 The progressive trench curvature during rollback implies block rotation, likely accommodated by the
665 NE-striking dextral faults (Fig. 11B). Normal faults rotated together with s_3 which became NE-SW (T_{34}
666 tensor – Fig. 11B). This progressive rotation can explain the widespread distribution of NW normal
667 fault strikes, as shown in our data (Fig 6 with NW- normal faults striking from N110 to N150).
668 Compression related to Anatolia extrusion remains EW during Miocene times and is accommodated in
669 NE-striking dextral faults (tensor T_4 -Fig. 7; and Fig. 11A and B). Our AFT and structural data show
670 that the Pelagonian fault acted as major dextral strike-slip fault during middle Miocene. The Pelagonian
671 fault accommodated not only EW compression but also accommodated lateral different amounts and
672 styles of continental extension during trench curvature and block rotation: a large and younger amount
673 of extension in the Cyclades/South Evvia/Attica accommodated by detachment faulting (Avigad and
674 Garfunkel, 1989; Gautier et al., 1993; Liati et al., 2009 ; Tschegg and Grasemann, 2009 ; Jolivet et al.,
675 2010a; Krohe et al., 2010; Iglseider et al., 2011 ; Grasemann et al., 2012, 2018 ; Scheffer et al., 2016;
676 Coleman et al., 2019) and less extension in Central Greece (north of the Pelagonian fault) mainly
677 accommodated by high-angle normal faults (Fig. 11A and B).

678 During the Plio-Quaternary, Central Greece evolved into a pure extensional tectonics regime, with
679 almost radial extension and no more E-W shortening (tensor T_{12} - Figs. 5 and 10E and 11C). This
680 implies that westward extrusion of Anatolia became fully accommodated by the North Anatolian Fault
681 (NAF, as also suggested by Armijo et al., 1996; Reilinger et al., 1997) leading to the formation of the
682 Anatolia/Aegean microplate. The middle Miocene normal faults were used to define NW-striking
683 oblique rifts, with newly formed E-striking normal faults (Fig. 11C).

684 Our study suggests therefore that the Corinth and Evvia rifts are not opening in response to westward
685 propagation of the NAF (Armijo et al., 1996) but are instead related to progressive strain localisation at
686 lithospheric scale controlled by both a change in the direction of extension and the presence of inherited
687 structures. This change in the direction of extension from NE-SW to N-S during the Plio-Quaternary
688 cannot be explained by the progressive trench curvature and block rotation during trench retreat. It can
689 be more likely related to slab deformation at depth, as exemplified by the formation of the Kephallonia
690 strike-slip fault (Evangelidis, 2017; Bocchini et al., 2018).

691

692 **Conclusions**

693

694 Based on new structural data, stress tensor analysis and AFT data in Central Greece, we draw the
695 following conclusions

696 - middle Miocene basins in Central Greece are controlled by both NW-striking normal faults and NE-
697 striking dextral strike-slip faults. The Pelagonian fault that limits Pelagonia-derived rocks to the north
698 from Adria-derived rocks to the south is an example of such dextral strike-slip active during the middle
699 Miocene.

700 - Apatite Fission Track data constrain middle Miocene local exhumation near NW-striking high-angle
701 normal faults in Central Greece, confirming their middle Miocene activity.

702 - New Apatite Fission Track data for Central Greece suggest a significant difference in the amount of
703 exhumation between Central Greece and the Cyclades. This difference in the amount of
704 exhumation/exhumation is found to be accommodated by the Pelagonian dextral strike-slip fault.

705 -The co-existence of NE-striking dextral strike-slip and NW-striking normal faults during the middle
706 Miocene is associated with an almost N-S extension related to trench retreat and an E-W compression
707 related to westward extrusion of Anatolia.

708 -The progressive trench curvature during slab rollback implies a progressive rotation of NW-striking
709 normal faults. This rotation is proposed to be accommodated in Central Greece by the Pelagonian fault.

710 - During the Plio-Quaternary, a change in extensional direction from NE-SW to N-S implies the
711 formation of E-W normal faults inside NW-striking fault zone, defining oblique rift systems.

712

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721 2003; Thomson et al., 2009; Vamvaka et al., 2010; Coutand et al., 2014; Schenker et al., 2015; for the
722 Cyclades/South Evvia/ Attica datation: Hejl et al., 2002, 2008; Ring et al., 2003, 2007; Brichau et al.,
723 2006, 2008; Seward et al., 2009; Berger et al., 2013; Soukis and Stockli, 2013; Seman, 2016; Grasemann
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725 structural and thermochronology data from the text, tables and figures, as well as our complete dataset
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1307 **Figure captions**

1308 **Figure 1:** Simplified tectonics map of the Aegean with different continental terranes (Rhodope,
 1309 Pelagonia, Adria; modified after Bradley et al., 2013; Papanikolaou, 2013; Brun et al., 2016), deep
 1310 basins and/or oceans (Vardar, Pindos) and main faults or deformation zones: NAF: North Anatolian
 1311 Fault; NAT: North Aegean Trough; CHSZ: Central Hellenic Shear Zone; MIF: Myrthes-Ikaria Fault,
 1312 the Pelagonian Fault. middle Miocene basins in dark Orange and syn-tectonics Miocene plutons
 1313 (Koukouvelas and Kokkalas, 2003; Kokkalas and Aydin, 2013) in red. Low-temperature data from Hejl
 1314 et al., 1999, 2008; Most, 2003; Thomson et al., 2009; Vamvaka et al., 2010; Coutand et al., 2014;
 1315 Schenker et al., 2015 for Pelagonia; Hejl et al., 2002, 2008; Ring et al., 2003, 2007; Brichau et al.,
 1316 2006, 2008; Seward et al., 2009; Berger et al., 2013; Soukis and Stockli, 2013; Seman, 2016;
 1317 Grasemann et al., 2018; Schneider et al., 2018 for the Cyclades. Curved arrow: North Aegean
 1318 clockwise block rotation (Horner and Freeman, 1983; Kissel et al., 1986, 2003; Duermeijer, 2000; van
 1319 Hinsbergen et al., 2005, 2006; Bradley et al., 2013) and counterclockwise rotation in south Aegean

1320 (van Hinsbergen et al., 2007, 2010; van Hinsbergen and Schmid, 2012). Black arrows: average
 1321 directions of Anatolia westward extrusion and southward Hellenic trench retreat related to slab
 1322 rollback (Reilinger et al., 2006). Dashed box: study area in Central Greece. Inset: present-day GPS
 1323 velocity field (modified from Hollenstein et al., 2008).

1324

1325 **Figure 2:** Tectonic map of Central Greece (location in Fig. 1) gathering our interpretation (see text for
 1326 details) and already published data (geology simplified from Bornovas and Rondogianni-Tsiambaou,
 1327 1983; Faupl et al., 2007; Nirta et al., 2015; and tectonics interpretation from Roberts and Jackson,
 1328 1991; Gautier and Brun, 1994; Jackson and McKenzie, 1999; Goldsworthy et al., 2002; Kokkalas et al.,
 1329 2007; Lykousis et al., 2007; Bell et al., 2009; Kokkalas, 2010; Krohe et al., 2010; Walker et al., 2010)
 1330 . Coexistence of NW-striking normal faults (red) and NE-striking dextral strike-slip faults (Pelagonian
 1331 fault strike-slip corridor in orange) during middle Miocene basins deposition (in yellow); and younger
 1332 E-W normal faulting (black) during Plio-Quaternary basins deposition (in light yellow). Grey
 1333 diamonds: AFT samples. Dashed boxes: location of local studies (Limni basin shown in Fig. 3, Loutra
 1334 Ypatis shown in Fig. 4 and Kymi basin shown in Fig. 6).

1335

1336 **Figure 3:** Structural features of the Limni basin (location in Fig. 2). A/ structural map (modified from
 1337 Bornovas and Rondogianni-Tsiambaou, 1983; Bono et al., 1998) of the Limni basin with basin bedding,
 1338 basement foliation and main inferred normal faults (NW-striking in red and E-striking in black). “I, II,
 1339 IV, V”: sites of measurements shown in B/. Grey diamonds: AFT samples. B/ Stereonets for
 1340 measurements made in different key locations, shown in A/, with fault and basin bedding. Dip-slip
 1341 slickenlines associated with NW-striking normal faults are represented by red circles and oblique
 1342 slickenlines associated with NW-striking sinistral faults are represented by purple circles. Slickenlines
 1343 with a rake $\leq 45^\circ$ are considered as oblique. C/ NNE-SSW a''-a cross section (profile drawn in A/).
 1344 Fault numbering shown also in map A/. D/ Outcrop pictures. Left: dip-slip slickenlines in NW-striking
 1345 normal fault plane (location II shown in A/, B/ and C/); right: cross-cutting relation between NW-
 1346 striking and E-striking normal fault (location I shown in A/, B/ and C/).

1347

1348 **Figure 4:** Structural features in the Loutra Ypatis area (location in Fig. 2). A/ Structural map (modified
 1349 after Bornovas and Rondogianni-Tsiambaou, 1983; Faupl et al., 2007; Nirta et al., 2015) with main
 1350 inferred normal faults (NW-striking in red and E-striking in black). “I, II, III, IV, V”: key locations of
 1351 measurements shown in B, “a,b,c”: location of outcrop pictures shown in C/. Arkitsa fault geometry
 1352 from Jackson and McKenzie, 1999; Kokkalas et al., 2007. Grey diamonds: AFT samples. B/ Stereonets
 1353 for fault measurements made in different sites (shown in A/) with NW-striking normal faults in red and
 1354 E-striking normal faults in black. Dip-slip slickenlines associated with NW-striking normal faults et E-
 1355 W normal faults are respectively represented by red and black circles. Oblique slickenline associated
 1356 with NW-striking sinistral fault is represented by purple circle. C/ Outcrop pictures: slickenlines in
 1357 Kamena Vourla fault planes (locations a and b in A/) and E-striking fault plane (location c in A/).

1358

1359 **Figure 5:** Stress inversion results (*Fault and Stress Analysis* software) for Plio-Quaternary (A) and
 1360 middle Miocene (B) fault families measured in Limni (Fig. 3) and Loutra Ypatis (Fig. 4) area. A/ Stress
 1361 inversion tensor result T_{12} for E-striking normal faults (family 1) and NW-striking oblique (sinistral)
 1362 faults (family 2): sub-vertical s_1 , sub-horizontal and radial extension with N-S s_3 . A-1: Left lower
 1363 hemisphere Schmidt stereographic representation of the fault slip data. A-2: lower hemisphere Schmidt
 1364 stereographic projection of the principal stress orientations. Circle, square and triangle correspond to
 1365 s_1 , s_2 , s_3 , respectively. A-3: Plio-Quaternary schematic tectonics map with N-S extension associated
 1366 with E-striking normal fault and oblique slip on NW-striking faults and Plio-Quaternary basins. B/
 1367 Stress inversion tensor result T_3 for NW-striking normal faults (with dip slip motion, family 3) with NE-
 1368 SW s_3 . B-1 and B-2: same convention as in A/, B-3: middle Miocene schematic tectonics map with NE-
 1369 SW extension with dip-slip motion on NW-striking normal faults and middle Miocene basin deposition.

1370

1371 **Figure 6:** Structural features of the Kymi basin area (location in Fig. 2). A/ Structural map (modified
 1372 after Bornovas and Rondogianni-Tsiambaou, 1983; Bradley, 2012) of the Kymi basin with inferred
 1373 main NW-striking normal faults (red) and NE-striking dextral strike-slip faults (orange), basin bedding
 1374 and basement foliations. Large scale folds from West to East: Amarynthos antiform, Kymi syncline,
 1375 Almyropotamos antiform (Xypolias et al., 2003). "I, II, III, IV, V, VI, VII": zones of measurements
 1376 shown on stereonets in B/. Grey diamonds: AFT samples. B/ Stereonets for fault measurements and
 1377 basin bedding conducted in several key locations (shown in A/). C/ Outcrop pictures showing sub-
 1378 horizontal slickenlines on NE-striking fault plane (zone IV in A/). D/ Outcrop picture in location III
 1379 showing new NE-striking shistosity inside a NE-striking sub-vertical fault zone. E/ The Kymi basin
 1380 cross-section (profile drawn in A/) orthogonal to the NE-striking Pelagonian dextral strike-slip fault

1381

1382 **Figure 7:** Stress tensor inversion result T_4 for NE-striking dextral strike-slip faults (family 4, measured
 1383 in Kymi area, Fig. 6). A/ Left lower hemisphere Schmidt stereographic representation of the fault slip
 1384 data. B/ lower hemisphere Schmidt stereographic projection of the principal stress orientations. Circle,
 1385 square and triangle correspond to s_1 , s_2 , s_3 , respectively. C/ Schematic tectonics map of the Kymi basin
 1386 deposition controlled by NE-striking strike-slip faults with N-S extension and E-W compression,
 1387 compatible with observed large-scale open folds.

1388

1389 **Figure 8:** Single crystal apatite fission track age distribution of the samples presented in radial plots
 1390 (Galbraith, 1990, 2005) and age spectra. Samples location in Fig. 2. Radial plots were made using the
 1391 Trackkey software (Dunkl, 2002). The light-blue shade represents the estimated stratigraphic age of
 1392 the sediment for each sample. The grey arrows point to the Oligocene cooling phase and the red arrows
 1393 to the Miocene cooling phase, if present. Red vertical dashed line: Oligocene-Miocene boundary. A/

1394 *Results for Sample CG03; B/ Results for Sample CG08; C/ Results for Sample CG11; D/ Results for*
 1395 *Sample CG13; E/ Results for Sample CG14; F/ Results for Sample CG16.*

1396

1397 **Figure 9:** *Synthesis of low-thermochronology data in Central Greece and the Cyclades, highlighting*
 1398 *the major differences in exhumation history between the Cycladic Blueschist Unit (CBU, in blue) and*
 1399 *the Pelagonian-derived rocks (in pink). A/ Simplified map (geology simplified from Papanikolaou,*
 1400 *2013; Brun et al., 2016) with a synthesis of low-temperature thermochronology ages from this study*
 1401 *(circle for AFT) and from previous studies (diamond for AFT, triangle for Zircon Fission Track-ZFT,*
 1402 *hexagon and square for (U-Th)/He age in respectively Zircon and Apatite) in both Central Greece and*
 1403 *the Cyclades. Data from Hejl et al., 1999, 2008; Most, 2003; Thomson et al., 2009; Vamvaka et al.,*
 1404 *2010; Coutand et al., 2014; Schenker et al., 2015; and Cyclades/South Evvia/Attica datation from Hejl*
 1405 *et al., 2002, 2008; Ring et al., 2003, 2007; Brichau et al., 2006, 2008; Seward et al., 2009; Berger et*
 1406 *al., 2013; Soukis and Stockli, 2013; Seman, 2016; Grasemann et al., 2018; Schneider et al., 2018). B/*
 1407 *Low-temperature thermochronology ages along a NE-SW transect (location as black line in A/)*
 1408 *orthogonal to the Pelagonian fault. AFT, ZFT, and (U-Th)/He on Zircon and Apatites ages respectively*
 1409 *as diamonds, triangles, stars and square. AFT data from this study as circle. Colors refer to different*
 1410 *references (see A/). Thick pink and blue lines: mean low temperature age calculated in Pelagonian*
 1411 *rocks and in the Cycladic rocks. Thick dashed line: Pelagonian fault. See text for further explanations.*
 1412 *References: (a) Berger et al., 2013 - (b) Brichau et al., 2006 - (c) Brichau et al., 2008 - (d) Coutand et*
 1413 *al., 2014 - (e) Grasemann et al., 2018 - (f) Hejl et al., 1999 - (g) Hejl et al., 2002 - (h) Hejl et al., 2008*
 1414 *- (i) Most, 2003 - (j) Ring et al., 2003 - (k) Ring et al., 2007 - (l) Schenker et al., 2015 - (m) Schneider*
 1415 *et al., 2018 - (n) Seward et al., 2009 - (o) Soukis and Stockli, 2013 - (p) PhD of Seman, 2016 - (q)*
 1416 *Thomson et al., 2009 - (r) Vamvaka et al., 2010.*

1417 **Figure 10:** *Stress inversion and stress compatibilities between NE-striking dextral faults, NW-striking*
 1418 *high-angle normal faults and E-striking high-angle normal faults. A/ Stress inversion results for the*
 1419 *combination of NW-striking normal faults (with dip-slip, family 3) and NE-striking dextral strike-slip*
 1420 *(family 4). B/ Inferred stress tensor solution T_{34} . Same conventions as Fig. 5. WNW s_1 and NNE s_3 ; C/*
 1421 *Stress inversion results for the combination of back-rotated NW-striking normal faults (with dip-slip,*
 1422 *family 3r) and NE-striking dextral strike-slip (family 4). D/ Stress tensor solution T_{3r4} , with back-*
 1423 *rotated NW-striking normal faults. N-S s_3 and E-W s_1 . E/ Tectonic regime diagram (Armijo et al., 1982;*
 1424 *Philip, 1987; Célérrier, 1995). Left: each stress tensor is represented by an open circle. Center: the*
 1425 *three tectonics regimes of Anderson (1905) are designated by the vertical principal stress S_v . Right:*
 1426 *stress tensor aspect ratio $r_0 = (\sigma_1 - \sigma_2) / (\sigma_1 - \sigma_3)$.*

1427

1428 **Figure 11:** *Schematic tectonics reconstruction of Central Greece from middle Miocene to Present*
 1429 *(simplified from Royden and Papanikolaou, 2011) and position of the Hellenic trench and emerged*
 1430 *area in the Aegean domain in inset (right corners). A/ middle to late Miocene before block rotation*

1431 *(back-rotated position): with NE-striking dextral strike-slip faults and restored position of the NW-*
 1432 *striking normal faults (almost E-striking after a 30° of back-rotation), respectively accommodating*
 1433 *initiating westward Anatolia extrusion and ongoing Hellenic trench retreat. On the right: middle*
 1434 *Miocene Stress Tensor before rotation (T_{3r4} , Fig. 10).B/ middle to late Miocene after block rotation(in*
 1435 *present-day configuration): distributed deformation with coexistence of normal faults and dextral*
 1436 *strike-slip fault. Block rotation, accommodated by dextral strike-slip faulting (see inset bottom left for*
 1437 *clockwise rotation consistent with dextral faults) and subsequent rotation of normal faults (red).*
 1438 *Extensional stress rotated subsequently from N-S (see A/) to NE-SW (stress tensor T_3 in red rectangle,*
 1439 *from Fig. 5). Shortening direction are similar to A/ in the strike-slip corridors (stress tensor T_4 in orange*
 1440 *rectangle, from Fig. 7). C/ Plio-Quaternary: Formation of E-striking normal faults inside pre-existing*
 1441 *NW-striking structures now associated to sinistral kinematics. Stress tensor T_{12} (from Fig. 7) : radial*
 1442 *extensional.*

1443

1444 **Table. 1.** *Position of each sample is given in columns coordinates. p_s , p_i and p_d correspond respectively*
 1445 *to spontaneous, induced and dosimeter track densities ($\times 10^4 \text{ cm}^{-2}$). N_s , N_i and N_d correspond*
 1446 *respectively to the total number of spontaneous, induced and dosimeter tracks. U is the calculated*
 1447 *Uranium density. $P(\chi^2)$ is the probability in % of χ^2 for ν degrees of freedom (where $\nu = \text{number of}$*
 1448 *crystals - 1). D_{par} is the mean fission-track pit diameter in μm corrected following Sobel & Seward*
 1449 *(2010) using a correction factor of 0.825. Central age calculated for each sample are given in the last*
 1450 *column.*