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KERASSIA-MILLIA COMPLEX: EVIDENCE OF A MESOZOIC-EARLY TERTIARY OCEANIC BASIN BETWEEN THE APULIAN CONTINENTAL MARGIN AND THE PARNASSUS CARBONATE PLATFORM IN WESTERN GREECE

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Abstract

The Kerassia-Milia Complex is a narrow, N-S trending melange unit, comprising Mesozoic-Early Tertiary ophiolitic and shallow-to deep-water sedimentary rocks, sandwiched between Early Tertiary terrigenous flysch of the Pindos-Olonos Zone. The complex provides evidence of a small oceanic basin located between the Apulian continental margin to the W and an intra-oceanic carbonate platform, the Parnassus Zone to the E. Late Triassic basaltic extrusion was accompanied by the deposition of shallow-water carbonate talus into a deep marine basin, followed by radiolarian and Late Cretaceous pelagic carbonate deposition. Geochemical analysis of basalts suggests an oceanic origin, possibly mainly as seamounts. In response to an inferred regional crustal extension event in the Late Cretaceous, ultramafic rocks were exposed on the seafloor, then eroded and redeposited within pelagic carbonates. During Early Tertiary closure of the Pindos ocean, basement highs (mainly lavas, reef limestone and serpentinite) were preferentially accreted, while the oceanic basement was subducted. The Complex was finally incorporated within a westward-propagating fold and thrust belt of Eocene-Oligocene age, formed by the closure of the Pindos ocean.

Introduction

The Pindos and Sub-Pelagonian Zones of mainland Greece have been reconstructed as a small ocean basin of Mesozoic-Early Tertiary age, sited between a large Apulian continent to the west and a smaller Pelagonian microcontinent to the east (Smith, 1979; Robertson and Dixon, 1984; Robertson et al., 1991). Particular importance is attached to the palaeogeographic position of the Parnassus Zone, a Mesozoic-Early Tertiary carbonate platform (Aubouin et al. 1970; Celet, 1972, 1977; Johns, 1977; Fig 1a), interpreted as forming either in an intra-continental (Celet, 1962, Dercourt, 1964; Fleury, 1980), or oceanic setting (Robertson and Dixon, 1984; Robertson et al., 1991). Ophiolitic rocks and associated shallow to deep-water sediments are sandwiched with 'Pindos flysch' of Early Tertiary age, located between deep-water passive margin sediments of the Apulian continental margin (Pindos-Olonos Zone; Green, 1982, Degnan and Robertson, 1990) to the west and the Parnassus Zone, a Mesozoic carbonate platform to the east. These ophiolite-related units are interpreted here as accreted remnants of a Mesozoic small oceanic basin, sited between Apulia and the Parnassus carbonate platform to the east.

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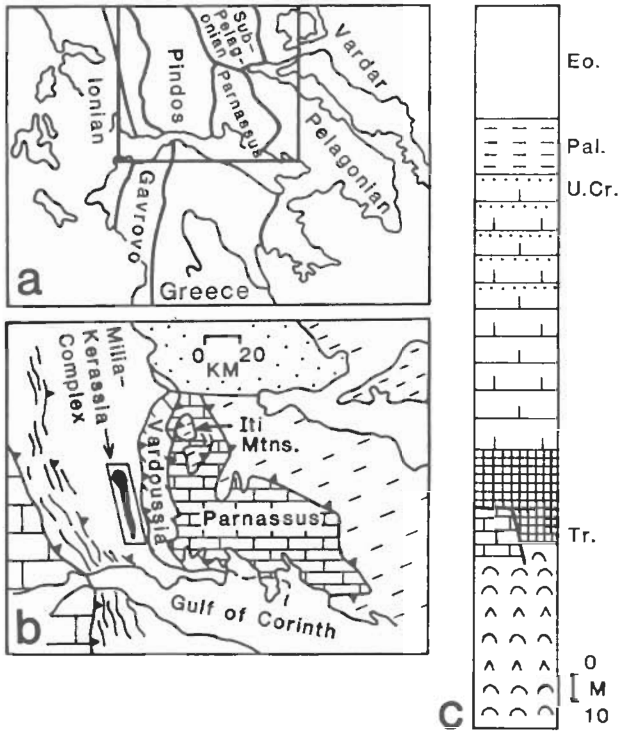

Fig 1 Setting of the Kerassia-Milia Complex. a, Outline of southern Greece showing the isopic (tectonostratigraphic) zones of Aubouin et al., 1970. Inset: area of b below; b, Sketch map of the regional structural setting; based on the Geological Map of Greece, 1983;); c, composite log of the Kerassia-Milia Complex. The complex is a melange and, thus reconstructing an overall succession may not be entirely valid.

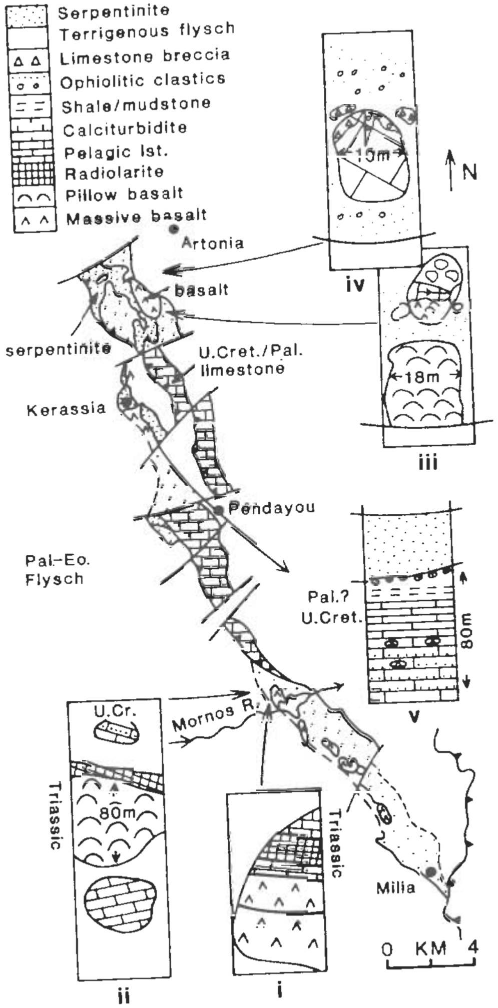

Fig 2 Map of the Kerassia-Milia Complex, modified after Beck (1980). Illustrative logs of local successions are also given (not to scale).

Regional setting

Evidence comes from an elongate north-south trending assemblage of thrust sheets, within the 'Pinde Etolie' dominantly comprising Palaeogene flysch and intercalated melange, including pillow basalts, serpentinite and deep-sea sediments (Fig 1b; Richter et al. 1991; Pe-Piper and Hatzipanagiotou, in press). To the west the 'Pindos Flysch' depositionally overlies Mesozoic deep-sea sediments of the Pindos-Olonos Zone; both were folded and thrust westward in the Early Tertiary. Further east the Pindos flysch is overthrust by Mesozoic passive carbonate margin sediments of the Vardoussia unit (Ardaens, 1978), interpreted as the westerly passive margin of the Parnassus carbonate platform (Celet, 1977; Fig 1b).

Gabbros, spilites and 'keratophyres' were mentioned within the 'Pindos Flysch' outcrop by Ktenas and Negris (1910) and later interpreted by Celet (1962) as 'lambeaux détaches du complexe ophiolitique et glissé sur le fond schisteux de la mer éocene lors du depot du flysch', a hypothesis that was supported by Beck (1975, 1980), following detailed mapping. In this scenario, ophiolitic olistostromes were expelled from an 'internal' segment of the Hellenides, within the Vardar (Axios) Zone far to the east, and thrust westward, first over the Pelagonian and Sub-Pelagonian Zones, then over both the Parnassus Zone and the Vardoussia unit (Fig 1a, b), before reaching the present position within the 'Pindos Flysch basin'; i.e. they represent the most westerly-travelled parts of a vast ophiolitic nappe derived from a single Mesozoic Neotethyan basin in the Vardar Zone. However, Beck (1980) also considered that some of the constituent lithologies (i.e. carbonates) might also have been derived more locally, from west of the Vardoussia unit. Several lines of evidence now indicate that the Kerassia-Milia Formation, as it was termed by Beck (1980) (our Kerassia-Milia Complex), formed entirely within the Pindos Zone: i) associated Upper Cretaceous pink pelagic limestones are lithologically correlated with the Pindos-Olonos zone to the west, but are disimilar to Upper Cretaceous successions exposed within the Vardar (Axios) Zone (e.g. Sharp and Robertson, this volume); ii) ophiolitic detritus interbedded with these Upper Cretaceous carbonates shows that ophiolitic rocks were present in the Pindos Zone long before the Early Tertiary (Eocene-Oligocene) westward thrusting of the Pelagonian Zone (and associated ophiolites) over the Parnassus Zone; iii) ophiolitic sheets that were indeed thrust westward over the Parnassus Zone to the east in the Early Tertiary (in the Iti Mountains, Fig 1b) are transgressively overlain by Upper Cretaceous shallow-water limestones (Celet, 1977). This Upper Cretaceous transgressive unit is, however, notably absent from the Kerassia-Milia Complex. Indeed, the ophiolitic units of the Vardar, Sub-Pelagonian Zone and the Kerassia-Milia unit are inferred to have formed in separate small ocean basins (Robertson et al., 1991).

Structure

The Kerasia-Milia Complex consists of rootless sheets of serpentinite and detached blocks, including pillow lava, shallow-water and deep-water carbonates and radiolarites (Fig 1c). In the north, near Kerassia (Fig 2) the complex is best exposed on the inverted, sheared, lower limb of a large, westward-facing recumbent anticline. The inferred upper limb is not exposed. The over-riding thrust sheet is mainly composed of Upper Cretaceous deep-water limestones, passing depositionally upward into Palaeocene hemipelagic mudstones, then into Eocene terrigenous flysch (Fig 1c). The thrust plane is immediately underlain by several metres of tectonic breccia, composed of pink micrite and

grey packstone and this, in turn, is underlain by debris flows ('wildflysch') composed of angular blocks of sandstone, calcitubidites and shale (up to 30cm in diameter) in a structureless, soft brown mudstone matrix. The debris flows are interpreted as having formed in a flexural foredeep ahead of advancing thrust sheets in the Early Tertiary.

Further south (Milia area; Fig 2), the Kerassia-Milia Complex is mainly composed of detached blocks of basalt, carbonates and radiolarian chert intercalated with the 'Pindos flysch', without any coherent stratigraphy.

Lithofacies

Triassic extrusives and associated sediments crop out extensively in the south (Milia area, Fig 2), where they comprise up to 80m-thick sheets of massive basaltic and doleritic extrusives, locally overlain by white silicified limestones, ribbon radiolarites and red silicified calciturbidites (Fig 2i). Further north, a block of massive lava and pillow lava (80m sized) is depositionally overlain by 15m of red ribbon radiolarite, in beds up to 0.20m thick, with grey shale partings (Fig ii). Rare, interbedded dolomitic and siliceous limestones are packed with *Halobia* shell fragments, confirming an Upper Triassic age. In this area, the enveloping flysch is dated as Lower Eocene, based on *Alveolina* in redeposited limestones (Beck, 1980). Disrupted successions, up to tens-of-metres thick, are well exposed along the road north of Kerassia, and include vesicular pillow basalt, lava breccia, hyaloclastite and feldspar-phyric lava (Fig 2 iii). In one local succession, pillow lavas, with interstitial carbonate sediment are overlain by 1m of disrupted red radiolarian mudstone and chert and then by 4m of debris flows, made up of basalt, radiolarite (with well preserved radiolarians) and red mudstone, set in a reddish grey volcaniclastic matrix. A block of recrystallised skarn-type limestone is also seen to be welded onto the base of a vesicular pillow lava flow, 8m thick.

Serpentinite sheets are mainly present in the north (e.g. 4.5km N of Kerassia; Fig 2). These mainly consist of serpentinised harzburgite, dunite and pyroxenite, with minor gabbro. Thrust sheets are up to 2km long, by 250m thick. North of Kerassia, the base of the largest serpentinite sheet is in thrust contact with terrigenous flysch, while the upper surface is stratigraphically overlain by mudstones, with minor interbeds of calcarenite. Beck (1980) reported that the serpentinites are overlain by Upper Cretaceous (Coniacian-Santonian) pelagic limestones. We observed that the successions are mainly tectonically inverted (based on grading and cross-lamination). Massive serpentinite locally passes stratigraphically upward into several metres of fragmental serpentinite and then into serpentinite-derived clastic sediments, with a matrix of pink Upper Cretaceous pelagic limestone (Fig 2v). Near the sheared contact with serpentinite, several-metre-thick horizons of serpentinite-derived breccia are present. Elsewhere (4km NE of Kerassia), a serpentinite sheet, associated with Upper Cretaceous pelagic carbonate, is tectonically intercalated with pink Palaeocene marls and Eocene terrigenous flysch.

Triassic shallow-water carbonates are exposed in the north (Kerassia area), closely juxtaposed with basalt. Individual blocks are up to 10m in size, composed of fine-grained stromatolitic limestone and medium-bedded grey dolomitic limestone, with bird's eye textures (Fig 2 1v). These blocks are mantled by carbonate breccias, up to 0.8m thick, composed mainly of sub-angular clasts, up to 25cm across. Fissures in the host carbonate blocks are filled with grey radiolarian micrite. Larger limestone blocks are in faulted contact with smaller blocks of cemented carbonate breccias, up to 5m in diameter, mostly composed of grey shallow-water carbonate in a matrix of fine-grained, reddish muddy carbonate, including nodules of replacement chert. Beck (1980) reported dolomitic limestones with ostracods and Megalodonts (1km S of Artonia, Fig 2). Available evidence, thus implies that the shallow-water limestone blocks are Upper Triassic, but are now detached within a matrix of Upper Cretaceous and/or Early Tertiary age.

Upper Cretaceous carbonates are important constituents of the Kerassia-Milia Complex in the north, as noted above. Thin-to medium-bedded pink, pelagic limestones, in units up to 60m thick are dated as Coniacian-Santonian (Upper Cretaceous), based on the presence of *Globotruncana* sp. (Fleury, in Beck, 1980). These sediments locally pass depositionally upward into several tens of metres of pebbly conglomerate with sutured, mainly angular, clasts of limestone and interbeds of ophiolite-derived clastics, ranging from silt, to sand and rudite in grade. Clasts are up to 0.3m in diameter (average 5-15cm) and include basalt, crystalline limestone (locally coralline), pink pelagic limestone, red chert, serpentinite and pyroxenite, in decreasing order of abundance.

Palaeocene-Eocene flysch is well exposed east of Kerassia, where Upper Cretaceous pelagic limestones, with ophiolite-derived debris pass depositionally upward into 8-9m of distinctive, brick red calcareous siltstone of Palaeocene age (Beck, 1980) and then into terrigenous flysch, dated as Middle Palaeocene (based on planktonic foraminifera) to Lower Eocene (on redeposited benthonic foraminifera (e.g. *Alveolina;* Fig 2v). Locally (i.e. 300m NW of Kerassia, Fig 2), distinctive Paleocene red mudstones are depositionally overlain by ophiolite-derived debris flows. Furthermore, Beck (1980) mentions that ophiolitic grains are present in associated flysch of Middle Eocene age. However, the surrounding 'Pindos Flysch' is almost entirely terrigenous, with little or no ophiolitic detritus.

The **Eocene flysch** mainly comprises well stratified, medium-to thick-bedded turbidites, locally channeled. Individual channels are up to 2-3m deep by 7m wide. Debris flows within these channels include angular clasts of grey limestone, quartzose sandstone and siltstone, but no ophiolitic material. There are also subordinate interbeds of Eocene calciturbidites, up to 0.6m thick (mostly 10-30cm), mainly composed of redeposited platform carbonate, with a sparry calcite matrix. Beck (1980) reports several other flysch facies of Middle Palaeocene-Lower Eocene age, the most notable being a conglomerate unit up to 50m-thick, with rudist debris, benthonic foraminifera (e.g. *Orbitoides*), dolomitic limestones (with Upper Triassic algae and ostracods), basic volcanics and radiolarian chert.

Basalt geochemistry

Eighteen samples of extrusive rocks were analysed from the Kerassia-Milia Complex by X-ray fluorescence, using the method of Fitton and Dunlop (1985). Well known 'immobile elements' (i.e. stable under low-grade weathering) were plotted on standard tectonic discriminant diagrams and MORB normalised "spidergrams" (e.g. Pearce et al., 1984; Fig 3 a, b).

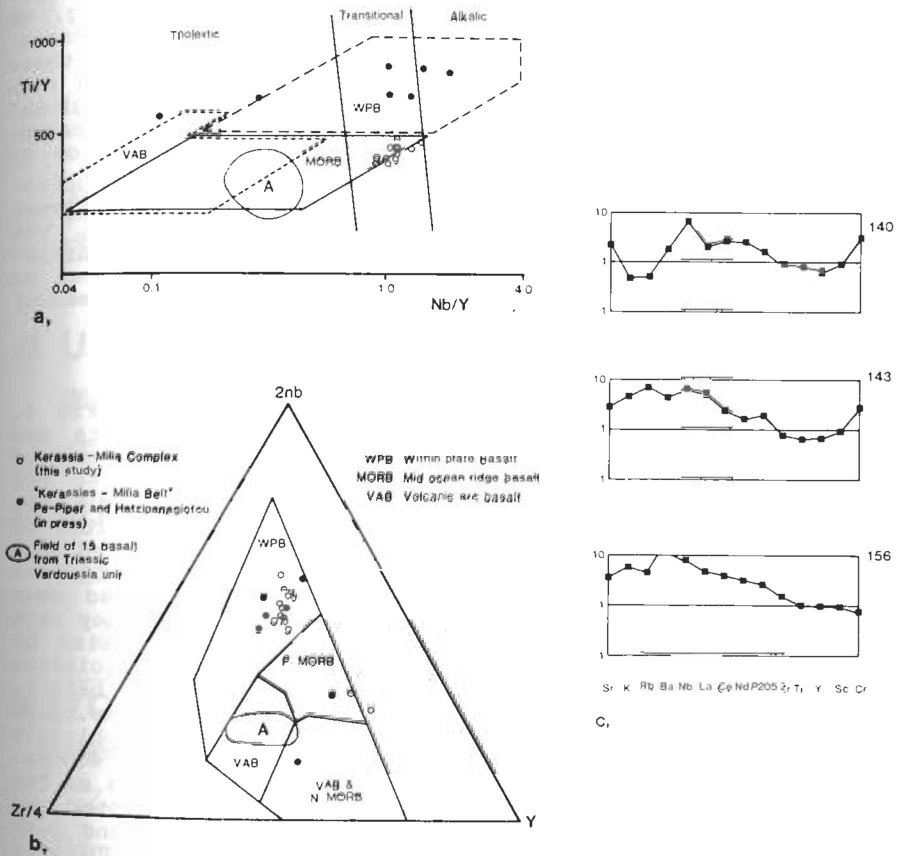

Fig 3a, b Tectonic discriminant diagrams "spidergrams" of basalts from the Kerassia-Milia Complex; c, MORB-normalised. See text for explanation. The field marked A represents the plots of 19 Triassic extrusive samples from the Vardussia tectonostratigraphic zone (our unpublished data).

On the Ti/Y versus Nb/Y diagram (Fig 3a) most samples plot in the MORB field. On the 2 Nb versus Zr/4 versus Y diagram (Fig 3b) they mainly plot on the WPB field, while two (from the southerly Milia area) plot in, or near the MORB field. Similar results are obtained using other discrimination diagrams (not shown here). Analyses plotted by Pe-Piper and Hatzipanagiotou (in press), are spread more widely on the various diagrams (Fig 3a, b). MORB normalised 'spidergams' of selected basalts indicate varying degrees of enrichment (Fig 3c). Based on our chemical data we conclude that the basalts relate to MORB and WPB settings. The WPB's reflect possible rift or ocean island (OIB) settings. Pe-Piper and Hatzipanagiotou (in press) favour an OIB setting. We have also analysed rift-related extrusives from the adjacent Triassic Vardoussia unit (Fig 3a, b; our unpublished data); these are quite different in composition and suggest a subduction zone influence (e.g. Pe-Piper and Piper, 1991). However, regional evidence of coeval subduction is lacking and the apparent subduction influence may instead relate to some combination of fractionation, continental contamination and/or a subduction component inherited from an earlier, unrelated subduction event (see discussion in Robertson et al., 1991). In summary, the striking chemical contrast between the Vardoussia and Kerassia-Milia extrusives strengthens the interpretation of the former as being rift-related and the latter as 'ocean island' (i.e. seamount basalts) and mid ocean ridge-type extrusives.

Interpretation: a small ocean basin

The fragmentary successions can be restored as shown in Fig 4. During Mid-Late Triassic?, pillow basalts, massive basalts and hyaloclastites were erupted in a narrow oceanic basin formed by rifting of the Vardoussia-Parnassus slope/platform unit to the east from the Apulian microcontinent to the west (Fig 4a). The width of this basin is unknown, but was possibly in the order of 100-150km. The extrusives mainly formed seamounts, associated with carbonate build-ups in the north (Kerassia area). Most of these build-ups are not now exposed. However, blocks were shed down slope onto basaltic crust in a deep-water setting, where they were overlain by further lava flows. Larger blocks were mantled by spalled limestone breccias, fissured and infilled with radiolarian micrite. Mixed sequences of lava breccia, pillow basalt, hyaloclastite, volcaniclastic sandstone, mudstone, limestone talus and radiolarite accumulated together; on a topographically irregular seafloor, possibly near submarine fault scarps. Elsewhere (i.e. Milia area), in more axial deep-water areas of the basin, more uniform pillowed and massive basalt were erupted and overlain by deep-water, siliceous radiolarian sediments and pink limestones, locally rich in redeposited *Halobia* sp. Jurassic sedimentation is not, at present documented from the Kerassia-Milia Complex, but may have been mainly radiolarian, as in the Pindos-Olonos Zone to the west (Fleury, 1980; Green, 1982).

Pink pelagic carbonates, typical of the Pindos Zone, accumulated in the Upper Cretaceous (Coniacian-Maastrichtian). During this time the ocean floor was faulted; igneous basement and sedimentary rocks were uplifted and underwent submarine erosion, shedding debris into pelagic carbonates (Fig 4b). Seafloor exposure of ultramafic rocks probably took place in response to a regionally important phase of extensional faulting. Extension in the Triassic, related to rifting and formation of a small ocean basin would have already placed ultramafic rocks at a high structural level. In such a setting a phase of renewed crustal extension would easily have exposed ultramafic rocks on the seafloor. Ultramafic clasts were then eroded from fault scarps by currents and gravity, and mixed with pelagic carbonates. Reworking apparently continued into Palaeocene-Lower Eocene time, suggesting either that extension continued, or probably simply that ultramafics continued to be exposed on the seafloor and eroded.

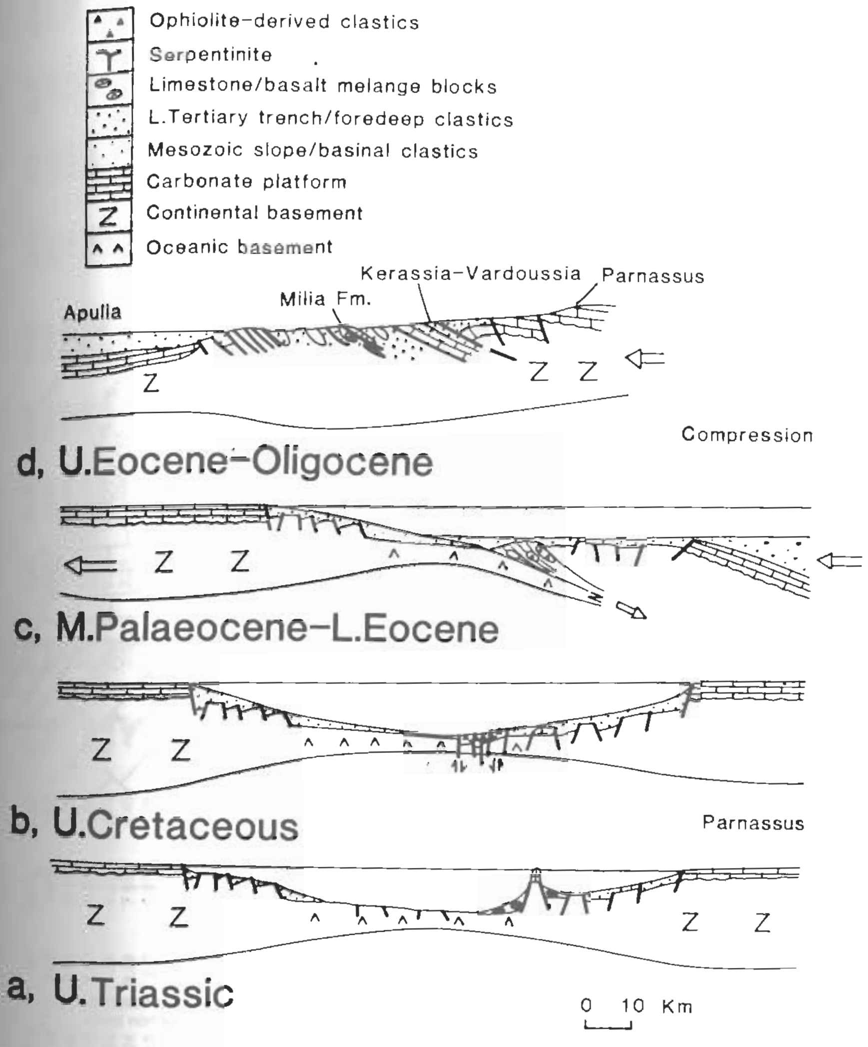

Fig 4 Inferred tectonic evolution of the Kerassia-Milia Complex; a, Late Triassic rifting. The basin between Apulia and Parnassus was floored by basalt and marginal? carbonate build-ups; b, Cretaceous crustal extension and faulting resulted in seafloor exposure of serpentinite; c, progressive east-west collapse of the Pindos ocean, with accretion of basement highs from the Kerassia-Milia small ocean basin; d, preservation of the Kerassia-Milia Complex as a folded thrust slice within a foreland propagating thrust and fold belt.

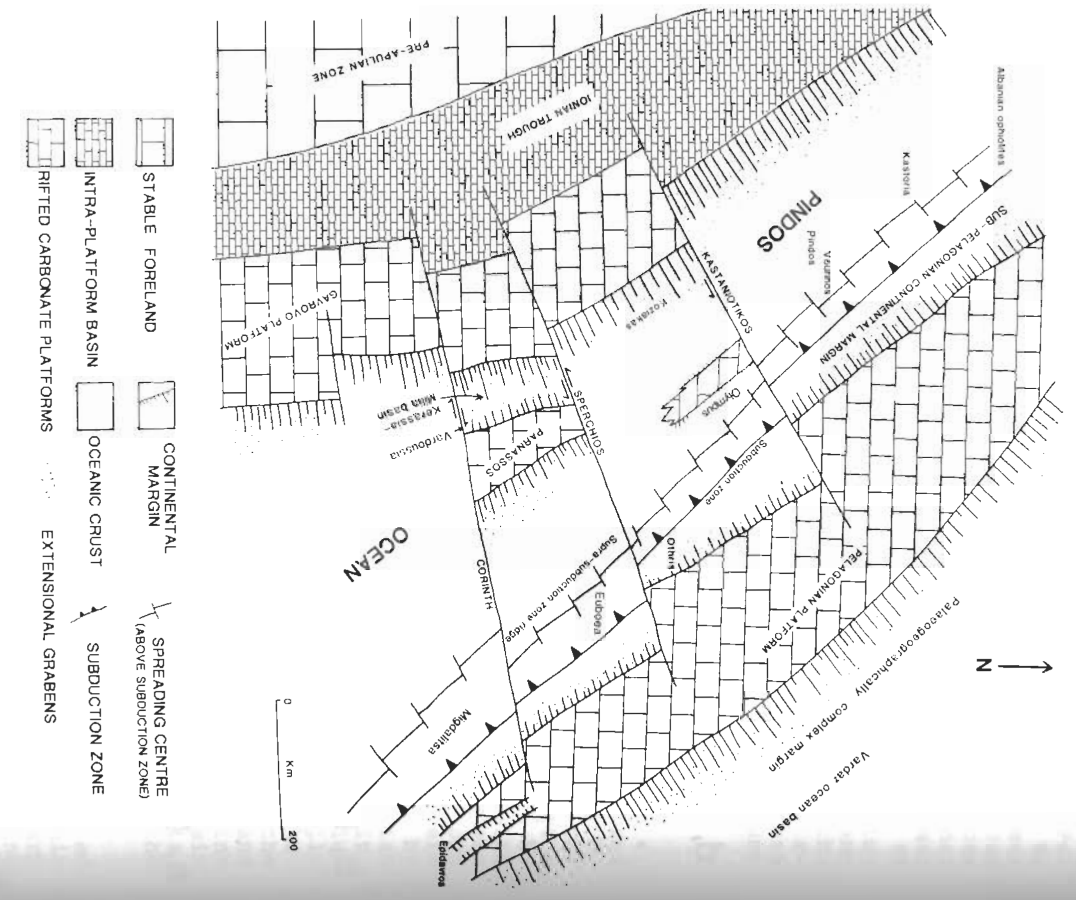

Fig 5 Inferred tectonic setting of the Kerassia-Milia basin in the Mid-Jurassic. Modified after Robertson et al., 1991.

	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156
SiO2	45.79	49.2	49.23	47.6	47	73.41	47.66	42.16	48.25	72.9	45.08	42.03	50.08	52.63	40.8	50.77	49.86	49.09
Al2O3	14.08	14.06	14.65	14.14	12.5	14.1	15.5	12.91	15.03	13.99	14.44	15.68	14.65	15.47	13.46	15.4	15.45	15.98
Fe2O3	8.29	8.41	7.88	8.99	8.85	2.17	7.89	9.71	9.2	3.1	10.24	8.47	7.03	7.61	7.66	8.81	7.97	8.85
MgO	7.15	10.69	9.28	9.78	7.37	0.22	4.88	3.63	4.89	0.32	6.05	4.22	7.74	7.56	2.98	8.15	7	8.03
CaO	11.93	6.98	7.59	9.86	11.85	0.27	8.79	13.32	8.74	0.28	10.2	13.08	5.22	3.44	13.79	5.13	7.88	5.41
Na2O	3.57	4.17	4.72	3.34	3.88	7.93	4.45	4.37	3.34	7.83	4.59	4.06	5.06	5.37	4.76	5.22	5.83	4.76
K2O	0.89	0.07	0.03	0.3	0.7	0.07	1.06	1.4	0.81	0.05	0.3	0.6	0.14	0.22	1.39	0.32	0.52	0.867
TiO2	0.94	1.06	1.19	1.03	0.98	0.23	1.63	1.46	1.66	0.24	1.6	1.46	1.31	1.56	1.1	1.56	0.82	1.518
MnO	0.15	0.19	0.17	0.17	0.16	0.04	0.36	0.23	0.31	0.04	0.31	0.34	0.44	0.25	0.23	0.15	0.12	0.208
P2O5	0.2	0.19	0.22	0.19	0.23	0.04	0.41	0.43	0.37	0.04	0.4	0.37	0.26	0.31	0.25	0.31	0.23	0.315
LOI	6.17	3.55	4.25	4.7	5.92	0.63	6.77	10.66	7.03	0.57	6.41	9.06	7.18	5.22	12.56	3.29	4.46	3.96
TOTAL	99.15	98.58	99.2	100.09	99.44	99.12	99.4	100.14	100.63	99.35	99.61	99.37	99.08	99.63	99	99.12	100.13	99.01
Sc	39	36	30	40	37	6	30	29	31	7	34	30	41	45	31	33	36	37
Ba	99	36	13	84	88	37	93	82	64	34	77	117	99	74	75	402	352	286
V	266	276	248	281	282	5	278	278	280	4	302	210	253	275	143	252	266	267
La	16	6	15	11	15	48	31	28	23	44	23	24	18	22	22	18	11	14
Ce	22	26	30	24	24	111	37	50	54	99	47	51	50	44	28	37	44	39
Nd	18	20	16	13	13	48	20	27	28	44	25	29	20	20	27	22	19	25
Cr	722	787	472	743	680	0	282	208	276	0	270	232	169	197	46	191	191	189
Ni	212	285	185	287	147	2	134	71	149	3	138	114	44	48	66	52	70	44
Cu	56	74	75	139	59	0	40	26	21	0	17	27	55	54	19	70	51	74
Zn	72	88	76	69	71	75	116	79	86	60	113	109	54	60	137	67	66	64
Pb	1	1	2	0	1	5	5	1	3	7	3	3	1	1	1	0	1	2
Th	2	0	2	0	2	8	3	2	2	9	3	3	2	2	1	3	4	4
Rb	15	1	1	4	14	1	11	21	8	1	4	12	2	2	32	4	4	9
Sr	320	266	168	522	339	58	224	172	199	43	207	242	205	192	110	458	299	429
Y	18	18	19	19	20	51	28	25	26	57	27	28	29	31	52	129	32	29
Zr	66	72	81	71	69	329	124	110	123	343	118	108	112	130	86	136	139	136
Nb	20	23	27	21	21	60	30	27	30	58	28	27	23	29	16	29	30	28

Table 1 Major-and trace-element chemical data of extrusives from the Kerassia-Milia Complex. Major-elements in weight percent oxide; trace-elements in parts per million. LO1 = Loss on ignition. Locations: Nos 139-143 pillow lava; 144-148 felsic lava; 145-150 pillow lava: Samples 139-150 are from south of Artonia on the road to Kerassia (Northern area); Samples 151-156 are green, aphyric lava, mainly pillowed (except 153: red, slightly vesicular lava). On road from Milia to Agroution (Southern area).

The inferred crustal extension event may relate to plate reorganisation that affected the entire Eastern Mediterranean area during the Upper Cretaceous (Robertson and Dixon, 1984; Clift in press). Known settings of comparable seafloor ultramafic exposure include the Tyrrhenian Sea (Western Mediterranean), formed by the break-up of a passive margin to form a Neogene small ocean basin (Kastens et al., 1988).

Compression leading to final closure of the Pindos ocean was first manifested in the transition from pink pelagic carbonate to red Palaeocene hemipelagic muds. Local reworking of ophiolitic materials continued during this time. The deep-water basin between Apulia and the Parnassus/Vardoussia platform/slope was then shortened, involving underthrusting and subduction of oceanic crust. Basement topographic highs (i.e. seamounts), created during both Upper Triassic rifting/spreading, and the Upper Cretaceous extensional event (i.e. ultramafics) were then preferentially detached and accreted into Eocene turbidites that accumulated in a trench setting. Meanwhile, the surrounding oceanic basement was subducted (Fig 4c). Similar melange containing igneous basement blocks is found beneath individual thrust sheets in the Pindos Zone in the Peloponnese (Formation de Blocs; De Wever, 1976), also interpreted as a subduction-accretion complex (Robertson et al., 1991). The deformed Pindos ocean basin, including the Kerassia-Milia narrow oceanic strand, was finally sutured, folded and thrust westward during the Late Eocene-Oligocene, related to collision of the African and Eurasian plates (Fig 4d). In summary, the inferred setting of the Kerassia-Milia basin with the Pindos ocean is shown in (Fig 5).

Conclusions

1 Ophiolite-related slices within the 'Pindos Flysch' basin, north of the Gulf of Corinth in mainland Greece, are interpreted as remnants of a small ocean basin that separated the Apulian continental margin to the west from a Mesozoic carbonate platform (Parnassus) and its westerly passive margin (Vardoussia unit), located within the Pindos ocean to the east.

2 Remnants of the small oceanic basin of Late Triassic age include vesicular extrusives, lava breccias, hyaloclastites, basalt-derived sands and muds. Carbonate build-ups were constructed on seamounts, from which talus was shed onto basaltic crust within the basin.

3 In more axial areas of the basin pillow lavas were blanketed by uniform Upper Triassic deep-water radiolarian sediments, associated with *Halobia* sp. limestones. Pelagic carbonates accumulated in the basin in the Upper Cretaceous.

4 During the Upper Cretaceous an inferred phase of regional crustal extension led to seafloor exposure of ultramafic rocks, which were then eroded by gravity and currents and redeposited within pelagic carbonates. Reworking continued into Palaeocene-Lower Eocene time.

5 During Paleocene-Upper Eocene, the inferred Mesozoic narrow oceanic basin closed. Terrigenous turbidites accumulated in a trench-type setting and basement highs were preferentially incorporated into a subduction/accretion complex, while the oceanic basement was subducted. Final suturing was achieved by folding and westward thrusting over the Apulian continental margin.

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