1. Introduction

The purpose of this study is to assess the timing of the onset of fine-grained carbonate deposits, the Vigla Limestone, of typical Maiolica facies, which occurs in the Ionian zone of western Greece (Fig. 1a). Accumulation of nannofossil-rich carbonates was believed to have started in the uppermost Jurassic, until Karakitsios & Koletti (1992) argued that the age of the base of this formation is early Berriasian and thus is synchronous throughout the Ionian zone.

The Ionian zone forms one of the major tectonic lineaments within Apulia (Adria), and was situated at the southern margin of Neo-Tethys ocean during Mesozoic times. Palaeogeographically, the Ionian zone originated as a deep-water basin when a pre-existing carbonate platform collapsed during Early Jurassic crustal extension in the area. Pelagic sediments (mainly carbonates, but also argillaceous and siliceous) accumulated up to Eocene time in a depositional environment remote from any major siliciclastic input. Early Jurassic syn-sedimentary faulting gave rise to intrabasinal differentiation, which resulted in basal successions with continuous sedimentation, and reduced sequences deposited on intrabasinal swells, punctuated by stratigraphic gaps (IGRS-IFP, 1966; Bernoulli & Renz, 1970).

Thiébault (1982) argued that as the Vigla Limestone laps onto Jurassic highs (intrabasinal swells) it uniformly blanketed seafloor topography when extensional tectonic activity ceased and the entire basin was undergoing thermal subsidence. The possibility of synchronous onset of this formation in the early Berriasian was used to support the idea that the basal Vigla Limestone formed the base of a post-rift sequence (Karakitsios, 1992, 1995). However, the Maiolica facies started to accumulate during the late Tithonian throughout the western Tethyan and Atlantic oceans (Bernoulli & Jenkyns, 1974; Ogg, Robertson & Jansa, 1983) and is widely regarded as the sedimentary record of a major palaeoceanographic event (De Wever & Thiébault, 1981; De Wever, Ricou & Fourcade, 1986; Baumgartner, 1987). Our biostratigraphic data from an important section in the Louros valley of western Greece (central Ionian zone), and revision of previous calpionellid datings of the base of the Vigla Limestone, shed light on this problem.

2. New biostratigraphic data

We have studied the lowest beds of the Vigla Limestone, near the village of Kato Kouklessi (Fig. 1b; 20°53′00″E, 39°22′17″N), which are composed of white, well-bedded, lime mud- to wackestones. The section is located on an inferred Jurassic high where a few metres of well-bedded, varicoloured cherts alternate with shaly partings (upper ‘Posidonia’ beds), and overlie the Lower Jurassic Pantokrator Limestone (Fig. 1c). The contact between the two formations is covered by scree at the locality of our section, but nearby, the top of the Pantokrator Limestone was found to be intruded by sedimentary dykes (Bernoulli & Renz, 1970). Well-preserved radiolaria were extracted from cherts (Fig. 1c, samples ASB1-1 and ASB1-4) at the base and at the very top of the upper ‘Posidonia’ beds (Danelian, 1989, 1995). High-resolution biostratigraphy recently achieved by radiolarians reveals
that the age of these cherts is middle–late Oxfordian (U.A.9: Baumgartner et al. 1995). Calpionella alpina Lorenz and Remaniella ferasini (Catalano) were identified in the sample AB1-3a, which is literally the first bed of Vigla Limestone overlying the radiolarian cherts (Fig. 1c). The same two species were identified in sample AB1-4, situated slightly above. We did not observe Calpionella elliptica in our material, and we suggest, therefore, that our samples belong to the Remaniella subzone (middle early Berriasian) of Remane et al. (1986).

These ages establish that a significant sedimentary hiatus occurs between samples ASB1-4 and AB1-3a (which are only 30–40 cm apart, Fig. 1c), spanning the Kimmeridgian and Tithonian, within a pelagic sequence of apparent sedimentary continuity between the radiolarian cherts and the Vigla Limestone.

3. Age of the basal Vigla Limestone

Most identifications dating from the late sixties and early seventies need to be revised in the light of more recent results from the study of Calpionellidae.

The Calpionella alpina and C. elliptica assemblage was regarded as Tithonian by I.G.R.S.-I.F.P. (1966) and Dalipi et al. (1971). However, these authors did not provide any further details concerning the size of C. alpina and it is now safer to consider this assemblage of late Tithonian–early Berriasian age. In fact, co-occurrence of medium-sized morphotypes of C. alpina and of C. elliptica would support a late early Berriasian age. When, however, the morphotypes of C. alpina are large, the age is either late Tithonian (in this case the reported C. elliptica was presumably misidentified with an oblique section of C. alpina), or the very end of the Tithonian (homeomorphs of C. elliptica: Remane, 1985; Remane et al. 1986). Karakitsios & Koletti (1992) reported the late early Berriasian assemblage (with medium-sized morphotypes of C. alpina and abundant C. elliptica) from the first few metres of Vigla Limestone at several localities.

In the sections of the central Ionian zone studied by Bernoulli & Renz (1970), the basal part of the Vigla Limestone can still be regarded as late Tithonian, based on the presence of Crassicollaria intermedia (abundant/frequent) and C. brevis (cf. Remane, 1985; Remane et al. 1986). The rare presence of Calpionella elliptica suggests that they were probably misidentified with oblique sections of C. alpina (as discussed above). Recently, Skourtsis-Coroneou & Manacos (1995) reported the presence of the Crassicollaria standard zone five metres above the base of the Vigla Limestone, which establishes that at least in parts of the external Ionian zone sedimentation of this formation started coevally in late Tithonian times.

The assemblage reported by B.P. (1971) from the base of the ‘Radiolarian Limestones’ (equivalent of the lower part of the Vigla Limestone) is problematic, because Calpionellites darderi is a species restricted to the early Valanginian and we now know that it does not co-occur with Calpionella elliptica (Remane, 1985).

In conclusion, the onset of Vigla Limestone sedimentation in the Ionian zone is diachronous. Nannofossil-rich carbonate sedimentation certainly started as early as the late Tithonian in some parts of the basin, but later in others, at different times of the early Berriasian (middle early
Berriasian, as established in this work; late early Berriasian: Karakitsios & Koletti, 1992), or even much later (Bernoulli & Renz, 1970, their section D, sample DB1514: late Valanginian or younger, dated by nannofossils).

4. Palaeocurrents and their role in reduced sequences

The presence of stratigraphic gaps in the Jurassic sequences of the Ionian zone was interpreted by some authors as being the result of subaerial erosion of the margins of tilted blocks which emerged during the Early Jurassic crustal extension phase (Thiébault, 1982; Karakitsios, 1992). However, indications of low rates of sedimentation and traces of non-deposition or sub-aquatic erosion in the reduced sequences suggest an open marine environment of sedimentation (Bernoulli & Renz, 1970). D.S.D.P. and O.D.P. drilling has demonstrated that stratigraphic gaps are widespread in the sedimentary sections of modern oceans; they occur in a variety of topographic settings, they cover different time intervals, and they are often a consequence of sea-floor erosion by oceanic currents (Jenkyns, 1986). Moreover, the application of sequence stratigraphy to condensed pelagic sediments provides new insight into the link between the hydrodynamic effect of bottom currents and the frequent sedimentary gaps which occur in reduced Tethyan sequences (Martire, 1992).

The biostratigraphic data discussed earlier from the Kato Kouklessi section establish that radiolarian-rich sediments (upper ‘Posidonia’ beds) encroached on the Jurassic topographic high of Kato Kouklessi during middle–late Oxfordian time (Fig. 2). A similar situation is found in the Umbria-Marche zone of Italy, where decreased current activity during the Oxfordian is thought to have allowed accumulation of radiolarian-rich sediments on Jurassic swells, on which bottom-current activity had previously prevented radiolarian accumulation (Baumgartner, 1990). The stratigraphic relations observed in the Ionian zone, specifically the onlap of pelagic sediments on topographic highs can be similarly interpreted. In the Ionian zone, bottom-current activity must have again increased during the Kimmeridgian and Tithonian, as sediments of this age are missing in Kato Kouklessi (Figs 1c, 2). Likewise, bottom-current activity probably played a major role in the dispersal of sediments in the Ionian zone for most of the Cretaceous. This could well explain the significant lateral variability in thickness of the Vigla Limestone (I.G.R.S-I.F.P., 1966).

The homogeneous character of the Vigla Limestone is due to the uniformity, in both size and shape, of the very small triangular flat prisms of *Nannoconus* tests (Noël & Busson, 1990). The onlap relationship of the Vigla Limestone on Jurassic intrabasinal highs and the apparent smoothing of the Ionian sea-floor topography can be interpreted as due partly to high rates of biogenic sediment accumulation of calpionellid and nannofossil-rich limestones (3.5–9.3 g/cm²/1000 yr; Thiébault, 1982), and partly to the re-distribution of these fine sediments by bottom currents. These currents would have prevented sedimentation on the topographic highs of the sea-floor, and can therefore be seen as the cause of the diachronous onset of the Vigla Limestone in the Ionian zone.

5. Conclusion

The role of oceanic bottom currents was probably significant in the Ionian zone, for most of Jurassic and Cretaceous
times, in preventing sedimentation on topographic highs inherited from Early Jurassic extension. Radiolarian and calpionellid dating near the Kato Kouklessi village of western Greece establish, for the first time, a significant hiatus in a sedimentary sequence of apparent continuity between the upper ‘Posidonia’ beds and the Vigla Limestone. It is likely that current activity decreased during the Oxfordian, allowing accumulation of radiolarian-rich sediments on a Jurassic high at Kato Kouklessi and increased again during the Kimmeridgian and Tithonian.

The base of the Vigla Limestone is not synchronous throughout the Ionian basin, contrary to earlier studies, but spans late Tithonian to early Berriasian (or later). The probable cause of this diachronity is dispersal of fine-grained sediment by variable current activity. This, combined with higher rates of nannofossil ooze accumulation through the Ionian basin, contrary to earlier studies, allows accumulation of radiolarian-rich sediments on a sedimentary sequence of apparent continuity between the Kimmeridgian and Tithonian.

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