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LATE PALEOZOIC, EARLY MESOZOIC PLATE TECTONICS OF THE WESTERN TETHYS.

G. M. STAMPFLI, J. MOSAR, A. DE BONO & I. VAVASIS[1]

ABSTRACT

A multi-disciplinary approach leads to the proposition of a new plate tectonic model for the western Tethyan area. The main points are: the Late Permian opening of the east Mediterranean ocean and of back-arc oceans within the Eurasian margin; both openings resulted in an Early Cimmerian collision zone within the Dinarides, Hellenides and Taurides corresponding to the closure of Paleotethys in these regions; a slab roll back of the back-arc oceans induced the opening of the Vardar; the subduction of the Vardar induced the opening of a small oceanic area in the external Hellenides and Taurides in Late Cretaceous.

KEY WORDS: Tethys; paleoreconstructions; Permian; Mesozoic; Neotethys; Meliata; Vardar; Mediterranean sea.

1. INTRODUCTION

There are still some confusions about what Tethys existed at what time. A consensus exists regarding the presence of a mainly Paleozoic ocean N of the Cimmerian continent(s), the Paleotethys, a younger late Paleozoic-Mesozoic ocean located S of this continent, the Neotethys, and finally a middle Jurassic ocean, the Alpine Tethys, an extension of the central Atlantic ocean in the western Tethyan regions. Additional late Paleozic to Mesozoic oceans complicate somewhat this simple picture and are shortly described below.

2. OCEANIC BASINS OF THE WESTERN TETHYS

The East Mediterranean-Ionian sea basin: A new plate model showing that the East Mediterranean domain corresponded to an oceanic basin since the Late Permian has been first proposed by Stampfli (1989, IGCP 276 conference) and later by Stampfli et al. (1991) and Stampfli & Pillevuit (1993). A recent study and comparison of the subsidence patterns of the Neotethys margins and the east Mediterranean and Ionian basins confirm this model (Stampfli et al. in press) . This rifting was concomitant with the opening of the Neotethys and the drifting of the Cimmerian continents since late Early Permian. In that model Apulia s.l.(Apulia and autochthonous "Ionian" units from Dinarides, Hellenides and Taurides) represents the western end of the Cimmerian continent.

The Meliata and other back-arc basins: A late closure of the Paleotethys (Late Permian to Triassic) on an eastern Europe transect of the Tethyan realm, implies the opening of back-arc basins of Late Permian or Triassic ages in a still active south-east European margin (Stampfli 1996). East of a paleo-Apulian promontory, this back-arc rifting graded into sea-floor spreading of the Hallstatt-Meliata (Kozur 1991) and Karakaya (Sengör et al. 1980; Okay & Mostler 1994) marginal basins. The western end of the Meliata back-arc rift (Southern Alps-Ivrea) aborted in Late Permian, whilst its eastern part (Hallstatt-Meliata-Dobrogea and Karakaya) continued spreading (e.g. Early Triassic MORB pillow lava of N-Dobrogea; Niculitel formation; Cioflica et al. 1980; Seghedi et al. 1990; Nicolae & Seghedi 1996).

[1] Institut de Géologie et Paléontologie, University of Lausanne BFSH-2 UNIL, CH-1015 Lausanne, Switzerland email:gerard.stampfli@igp.unil.ch; Jon.Mosar@ssi.unil.ch

Late Permian to Middle Triassic back arc basins are also known eastward in the Caucasus (Nikishin et al. 1997), NE Iran (Baud & Stampfli 1989), northern Afghanistan (Boulin 1988) and in the Pamirs (Khain 1994). Due to the collision of the Cimmerian blocks with the Eurasian margin (e.g. Stampfli et al. 1991; Alavi et al. 1997), these back arc basins disappeared during the Late Triassic.

The opening of both Meliata and east Mediterranean oceans induced the closure of the Paleotethys. The Apulian-Ionian western end of the Cimmerian block could not move much northward and was finally welded to Europe between the Late Permian and the Middle Triassic. This collision correspond to the gentle docking of Variscan elements drifting away from the active Eurasian margin (grouped here into the Pelagonain superterrane: Variscan elements from the Dinarides, Hellenides and Taurides) with elements derived from Gondwana (the Cimmerian blocks). The collision did not create major reliefs and the sedimentation stayed marine in many areas (Budva and Pindos). Middle Triassic flyschs or mélanges accompanying this collision are mainly found in Greece (e.g phyllite-quartzite group, Krahl et al. 1983; Liri flysch, De Bono et al. in press). A clear Cimmerian event has also been recognised in the Taurus in Turkey (Monod & Akay 1984) , but little is known on the location of the suture zone.

The Vardar ocean: The Karakaya-Küre back-arc (which is not a remnant of the Paleotethys, see Kozur 1997) is subducting to the south (Sengör et al. 1980; Tüysüz 1990; Pickett & Robertson 1996) and the southward propagation of this subduction zone is regarded, together with the opening of the Atlantic-Alpine Tethys system, as the tectonic event responsible for the opening of a younger back-arc ocean the Vardar (Stampfli et al. 1998). The Vardar ocean represented by obducted ophiolitic sequences found in the Hellenides and Dinarides resulted from the collapse (slab roll-back) of the Meliata ocean. It is obducting on the Pelagonian margin in Late Jurassic (e.g. Baumgartner 1985), then subducting under the Rhodope in Cretaceous times after the collision of the Paikon arc with the proto-Rhodope margin in Early Cretaceous. This northward subduction of the Vardar induced important Late Cretaceous arc activity in the Rhodope (Yanev & Bardintzeff 1997).

The Valais ocean: This rift located now in the western Alps, opened at the same time than the central Atlantic rift between Iberia and New Foundland (Stampfli & Marchant 1997; Stampfli et al. 1998). The oldest magnetic anomaly in that part of the Atlantic is M0 (Aptian). An oceanic connection with the Atlantic system existed through the Valais/Pyrenean/Biycay system (Stampfli 1993). The subsequent rotation of Iberia in Late Cretaceous (and opening of the Biscay ocean) is partially closing the Valais ocean, but final closure is taking place only in Early Oligocene.

The Arvi/Lycian ocean: Late Cretaceous ophiolites found in the external zones of the Taurides and Hellenides came from a new oceanic domain opening in Late Cretaceous due to the slab pull forces induced by the northward subduction of the Vardar slab under the Rhodope. This Late Cretaceous ocean could have separated the Bey Daglari from the Menderes massif (Poisson 1984) and from the Anamas Dag (Waldron 1984) and the Mamonia complex of Cyprus from the Taurus. As already proposed by Waldron it could extend westward to the Lycian ophiolites, then to the Arvi ophiolite of Crete which is also located within the external domain in the Hellenides (Bonneau 1984). The eastward junction with the intraoceanic Semail ocean is made through the Antalya nappes (Robertson 1993) and the Troodos ophiolites. In this context the Eratosthenes seamont (Robertson & party 1996) could have been part of a microcontinent south of this Late Cretaceous ocean, a possible continuation of the Ionian-Bey Daglari platform (A. Poisson oral comm.).

Tomographic images of the East Mediterranean subduction zone (Wortel & Spakman 1992) seems to confirm the presence of a double subduction zone with an abandoned northerly branch corresponding to a more internal suture (Vardar and/or Lycian slab). Therefore there has been a southward jump of the subduction zone into the east Mediterranean ocean and accretion (obduction) of the intervening terranes (the autochthonous/para-autochthonous units of the Hellenides and Taurides) which separated both oceans. This jump can be placed in Early Tertiary during or just after the flysch sedimentation in the Pindos area (Fleury 1980; Thiébault 1982) and the sealing of ophiolite obduction in the Lycian nappes by Lutetian deposits (Gutnic et al. 1979) and after the Early Eocene as suggested by paleomagnetic studies in Cyprus (Morris 1996).

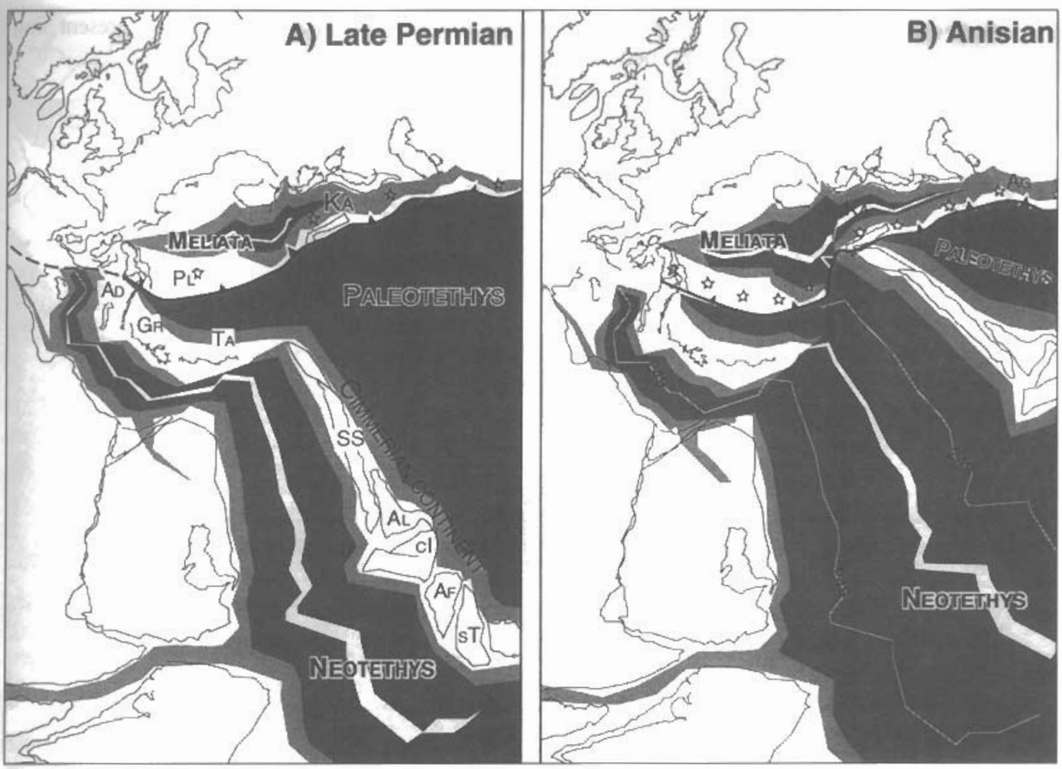

Fig. 1: Late Permian A) and Anisian B) reconstructions. Ad, Adria; Af, Central Afghanistan; Ag, Agh-Darband back-arc rift; Al, Alborz; cI, central Iran; Gr, autochthonous of Greece; Ka, Karakaya ocean; Pl, Pelagonian terrane; sT, south Tibet; Ta, Taurus. Star symbols represent volcanic arc.

3. THE RECONSTRUCTIONS

The maps present tentative new plate tectonic models developed for the western Tethyan area. They are modified from Stampfli et al. (1998) and Stampfli et al. (in press) and computed with the GMAP (Geographic mapping and paleoreconstruction package) program developed by Torsvik & Smethurst (1994) These reconstructions are based mainly on a review of the following articles and books:

- paleomagnetics: Embleton (1984); Van der Voo (1993); Powell & Li (1994); Jurdy et al. (1995)
- paleoreconstructions: Zonenshain et al. (1985); Ziegler (1988); Hutchison (1989); Ziegler (1990); Zonenshain et al. (1990); Torsvik et al. (1992); Baillie et al. (1994); Khain (1994); Niocaill & Smethurst (1994); Stampfli (1996); and the many contributions from the participants to the IGCP 369.

4. CONCLUSIONS

The analysis of subsidence patterns in the Neotethyan southern margin together with paleomagnetic, tectonic and sedimentological observations allow to define the major geodynamic evolution of this domain in the Late Paleozoic and Mesozoic. A first Early Carboniferous phase of rifting was followed by a second phase in Early Permian which gave birth in late Early Permian to Late Permian to the Neotethys oceanic floor extending to the East Mediterranean domain.

The Permian opening of the east Mediterranean basin also implies a subsequent Midlle Triassic closing of the Paleotethys in SE Europe (Dinarides, Hellenides and Taurides). This is well marked by a Cimmerian event recorded in these regions accompanied by the development of subduction related volcanism in Middle Triassic.

This model offers an alternative from models considering the east Mediterranean domain as a young oceanic entity. However the presence of a Late Cretaceous ocean just north of the present east Mediterranean basin is envisaged and is necessary to explain the westward escape of Apulia.

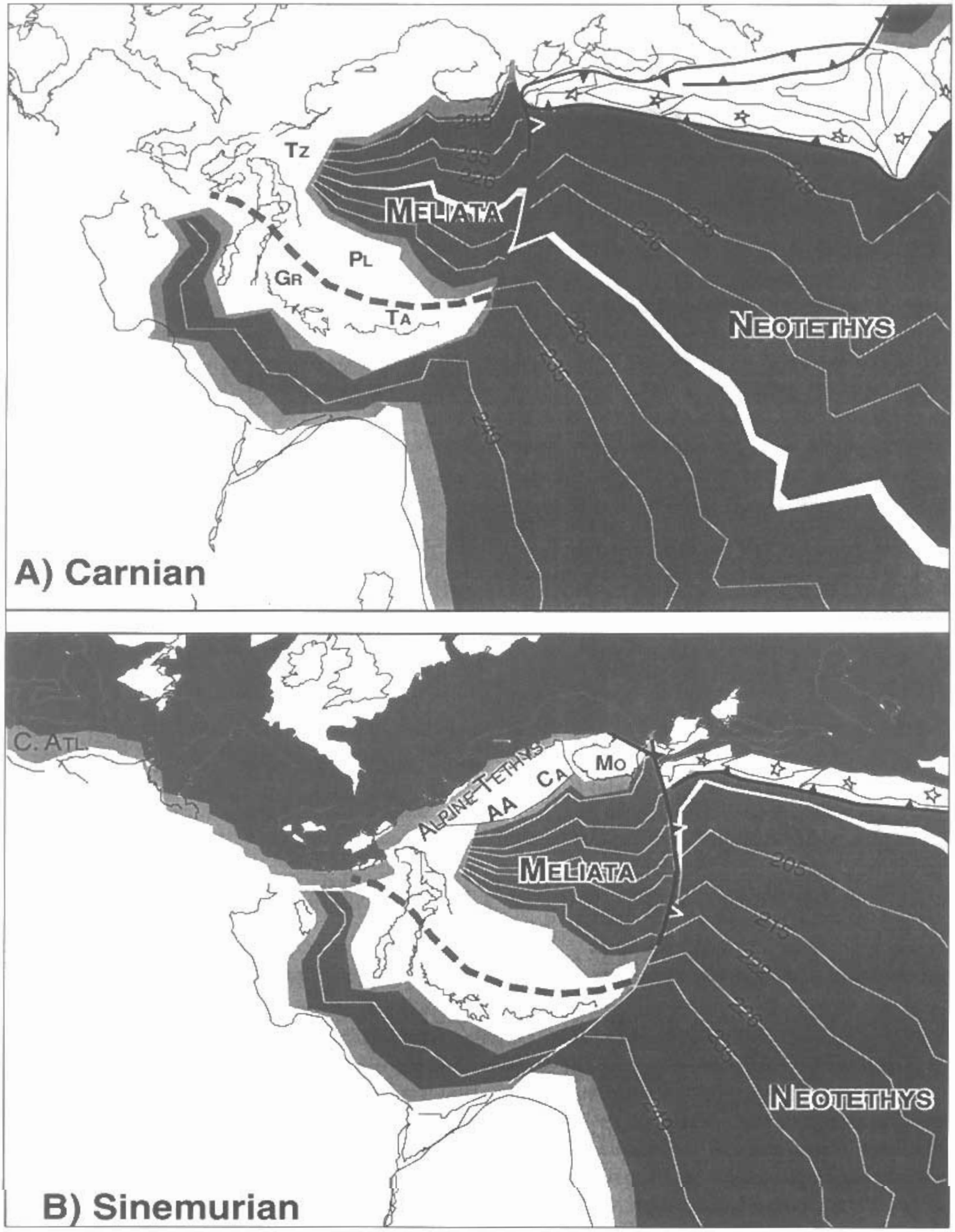

Fig. 2: Carnian A) and Sinemurian B) reconstructions. AA, Austroalpine; Ca, Carpathians; Gr, autochthonous of Greece; Mo, Moesia; Pl, Pelagonian terrane; Ta, Taurus; Tz, Tizia. Star symbols represent volcanic arc. Thick dash line is the Paleotethys suture and associated episutural basins (Budva, Pindos).

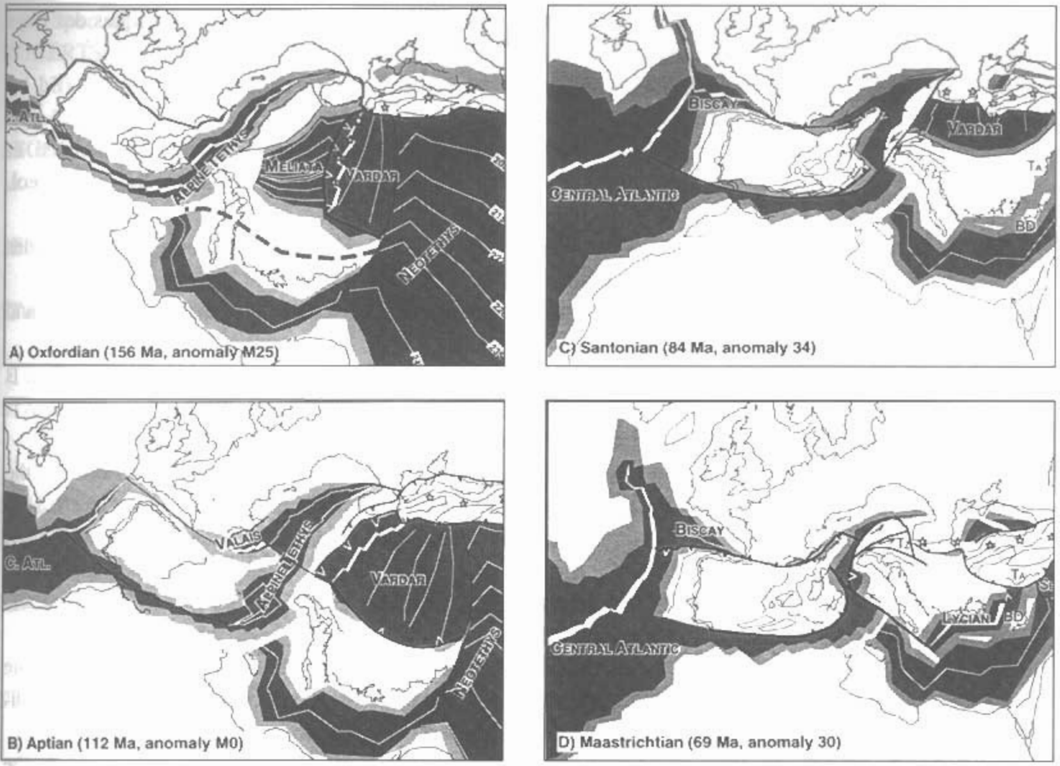

Fig. 3: Oxfordian A), Aptian B), Santonian C) and Maastrichtian D) reconstructions. BD, Bey-Daglari; SEM, Semail ocean; TA, Taurus. TZ, Tizia. Star symbols represent volcanic arc. Thick dash line is the Paleotethys suture and associated episutural basins (Budva, Pindos).

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