On the origin of some Eohellenic ophiolites : reply

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regional rotations into consideration, the shear-fabric data shown by Clift & Dixon (1998) indicate that the Migdhalitsa Ophiolite was probably derived from an ocean basin that was located palaeogeographically about to the north-west of the Pelagonian terrane, where, according to recent and latest reconstructions, the Vardar ocean evolved (Stampfli et al. 1991; Stampfli & Mosar 1998; Stampfli et al. 1998). Palaeogeographic evidence is lacking to support Clift & Dixon's conclusion that the Migdhalitsa Ophiolite was derived from the Pindos oceanic suture. This critique is neither directed towards Clift's and Dixon's interpretation of their geochemical data nor in principle towards their plate tectonic model.

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Reply

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We thank Rudolph Scherreiks for his detailed comments on our recent paper and for highlighting certain areas of special tectonic significance for reconstructions of the Hellenides. He is indeed correct in saying that the origin of the Subpelagonian ophiolites remains a controversial issue and we would like to take this opportunity to clarify some of the points raised, as they are important not only to reconstructing the paleoceanography of the Neotethys, but also to understand the tectonics of ophiolite formation and obduction. Traditionally the Migdhalitsa, as well as several other Hellenic Ophiolites (e.g. Pindos, Othris), have been considered as being derived from an eastern Vardar strand to the Neotethys that sutured during the Late Jurassic (Jacobshagen 1979; Vrielynck 1982; Baumgartner 1985). Alternative models have focused on the origin of the ophiolites and the timing of closure of the western Pindos and the eastern Vardar branchs of the Neotethys. The confirmation of Triassic-Eocene deep water pelagic and continental margin sediments within the Pindos Zone in the Peloponesos (Fleury 1980; Green 1983; Degnan & Robertson 1991, 1998), as well as in the Pindos Mountains of Northern Greece (Dio Dendra Group; Jones & Robertson 1991), indicates the presence of a deep water basin west of the Pelagonian Platform until final continental collision in the Paleogene. This is incompatible with Stampfli & Mosar's (1998) conclusion that suturing occurred in the Carnian (M. Triassic). Moreover, the identification of oceanic basalts of Late Cretaceous age in the Adheres Peninsula of southern Argolis, in contrast to the Jurassic Ophiolites of central and northern Argolis (Clift & Robertson 1989) and possibly also on the island of Evvia (Robertson 1990) demonstrate that a true oceanic basin remained open east of the Pelagonian Platform until the Eocene (cf., Stampfli et al. 1991; Stampfli & Mosar 1998).

45° rotation of peninsular Greece during the Neogene by bending of the Aegean Arc (Kissel & Laj 1988; Morris 1995) has accentuated the angular difference between the strike of the Hellenides and their continuation in western Turkey. However, the Aegean bend in the Alpine fold belts is not entirely a Neotectonic feature and reflects a real change in paleogeography, most markedly shown by the different ages of ophiolite obduction in Greece (Late Jurassic) and Turkey (Late Cretaceous). This difference was not recognized by Stampfli et al. (1991) and means that the Pindos suture lay SW not S of the Pelagonian Platform in southern Greece. This difference is important because the 90–107° rotation of the Argolis (Morris 1995) would restore a SSW-directed ophiolite obduction vector towards the ESE, almost along the strike of the restored pre-Neogene Pelagonian, not towards the Vardar suture as suggested by a simple internal origin. The independent rotation of Argolis relative to the rest of the Pelagonian Zone is clearly demonstrated by the WNW-vergent Tertiary thrusting in Argolis (Clift 1992) compared to the overall SW vergence of this age elsewhere. As a result the simple interpretation of a SW or SSW obducting Migdhalitsa Ophiolite does not necessarily translate into Vardar origin for this body. The structural data from Argolis alone are therefore equivocal in showing the root zone of the ophiolite.

At present there are inadequate radiometric or biostratigraphic age data to conclusively prove whether or not eastern or western ophiolites were formed at the same time, although, the Callovian age of the sedimentary cover to the Migdhalitsa Ophiolite (Baumgartner 1985) places this unit closer to the age of eruption of the western Subpelagonian ophiolites and is somewhat earlier than the Kimmeridgian Sithonia (Jung & Mussallam 1985) and Oxfordian Guevgeli Ophiolites (Danelian et al. 1996) of the Vardar Zone. On balance we conclude that the Migdhalitsa Ophiolite is most likely to be derived from the Pindos rather than Vardar suture, however we accept that more structural, radiometric and paleomagneic data are needed from additional parts of the Hellenides. Our paper should be seen as step in this direction.

Turning to the more detailed local comments, Figure 2 was not labeled as a road cut section because it is a simplified, not-to-scale diagram showing our proposed tectonic stratigraphy for the Argolis and does not represent any particular exposure. The SSW direction of obduction is derived from the asymmetric fold data of the radiolarian cover. The same vector is deduced from slickensides and shear planes within volcanics in the central Migdhalitsa area. These units are tilted gently towards the south, which would cause the poles to the shear planes to migrate to the north. Thus correcting for this effect would only make the trend shown in Figure 12A more pronounced. The SSW obduction vector for the central Migdhalitsa region is corrobrated by the independent work of Matthai (1989). Although the report by Scherreiks (1998) of a north to south direction of obduction in Evvia is more in accord with a Vardar origin for this ophiolite his observation cannot be directly interpreted without the benefit of paleomagnetic data, especially as this area lies within the zone of Neotectonic clockwise block rotation proposed by McKenzie & Jackson (1983). In contrast to the abstracts and short papers noted by Scherreiks (e.g., Stampfli et al. 1998) most comprehensive, recent syntheses (e.g., Doutsos 1993; Smith 1993) show a clear eastward thrusting of the western Subpelagonian ophiolites during the Jurassic. Most clearly the high temperature shear indicators within the sole of the Pindos Ophiolite, which must be Jurassic and obduction related, are towards the present NE (Jones et al. 1991) and thus offers no support to a Vardar-derived origin. On the basis of these data it seems likely that most of the Subpelagonian Ophiolites are of Pindos not Vardar origin of which the Migdhalitsa forms the southernmost example. However, we would certainly accept that there is still need for further geochronologic, structural and paleomagnetic data in the Hellenic Ophiolites and their associated units.

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