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GENERAL TECTONIC FRAMEWORK OF THE EASTERN MEDITERRANEAN

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Introduction

Our understanding of the tectonic framework of the eastern Mediterranean has greatly improved in the past ten years or so. New research has benefited from deep sea drilling by the Ocean Drilling Program (ODP), the extensive use of new techniques such as multibeam swath mapping, unexpected results from investigations of mud volcanoes and fluid seeps, and exploration of areas of potential resources like the Nile offshore. Furthermore, continued mapping on land – both geologic and geodetic (e.g. with GPS) – has provided new constraints for the evolution of the region. Nevertheless, the region remains poorly known because of difficulties not only in resolving many basic problems such as the age, nature, and configuration of the ocean basin but also in seeing below often thick Messinian salt or so-called cobblestone relief of the Mediterranean Ridge. This paper is a general overview of the tectonic framework of the eastern Mediterranean from the point of view of one researcher.

Basic neotectonic elements

Early views on the plate tectonic situation (McKenzie, 1972) have been largely confirmed by direct geodetic measurements of the surrounding landmass (Le Pichon *et al.*, 1995; McClusky *et al.*, 2000). Distribution of observation stations and the inability yet to survey submarine parts of the region means that details must be provided by seismicity and marine geophysical surveys.

Since mid-Cretaceous there has been convergence between the Eurasian and African plates. In broad terms, progressive plate collision occurs from east to west: it is essentially complete between both major plates in southeastern Turkey, underway along the Cyprus Arc, and just about to start along the Hellenic Arc. Since Late Miocene two microplates (the Anatolian and Aegean plates) have accommodated continued convergence of the African and Eurasian plates by moving laterally (westward tectonic escape) towards remaining regions of oceanic lithosphere (McKenzie, 1972; McClusky *et al.*, 2000). Within the zone of collision, smaller units accommodate movement locally (see below). To the south of the plate boundary lies the old original ocean basin dating probably from early Mesozoic (possibly originating from late Permian rifting along the north African margin) – the Ionian and Levantine Basins (fig. 1); but to the north, smaller basins record various stages in closure of the eastern Mediterranean basin.

The plate boundary follows the Cyprus and Hellenic Arcs with a southward offset which is smaller south of Cyprus than south of Crete where thinned continental basement continues beneath the Hellenic Trench to the Mediterranean Ridge. Similar thinned continental basement extends beneath the Anaximander Mountains from Turkey (fig. 2). It is not clear how the plate

boundary crosses through the region of the Anaximander Mountains. It could be speculated, however, that the region southeast of the Burdur fault zone in Turkey, west of Antalya, and including the Anaximander Mountains in the south, is an accommodation zone for relative plate interaction. The Anaximander Mountains form at least three independently moving, fault-bounded blocks. Subduction continues along the west and southwest arms of the Hellenic Arc but probably since late Miocene there is transpression along the Pliny-Strabo Trench system in the east.

North of the plate boundary lie basins of various ages. Several of these, like the Adana and Cilicia basins to the north of Cyprus (fig. 1) originated in late Oligocene to early Miocene (Robertson, 1998). Later developments caused their continuing tectonic evolution to diverge (e.g. uplift of the basins north of the suture zone in southeast Turkey but continuing subsidence in the Cilicia Basin). Other basins like the Rhodes and Finike Basin west and north of the Anaximander Mountains (fig. 1), respectively, are post Miocene (Woodside *et al.*, 2000a). The Antalya Basin probably dates from early Miocene, similar to the Cretan Basin, but shows evidence of increased subsidence and northward tilting in post Miocene time, in contrast to uplift in Cyprus and the adjacent Taurides. These basins are in general underlain by nappes emplaced from the north (Sage and Letouzey, 1990).

Collision of Eratosthenes Seamount with Cyprus in Pliocene time caused general uplift in Cyprus into the Pleistocene and subsidence of Eratosthenes with breakup and collapse (Robertson, 1998). Eratosthenes probably began as a fragment that rifted away from Africa in the Triassic on thinned continental crust and subsided prior to uplift in early Miocene. The collision has greatly reduced and almost stopped the convergence between Cyprus and Eratosthenes. Continued convergence is taken up in large measure by sinistral wrenching along the Latakia and Larnica Ridges east of Cyprus (Ben-Avraham *et al.*, 1995), and dextral wrenching along the Florence Rise to the west (Woodside *et al.*, 2000b). Transpressional and transtensional features are observed along both sides of the arc. Collision may also be responsible for breakup of the African plate between Egypt and Cyprus, with the creation of the intermediate Sinai Plate (Mascle *et al.*, 2000).

Tectonic activity related to plate interactions is partially obstructed by superficial deformation within the sediments overlying lubricating Messinian salts. Resulting structures associated with the Mediterranean Ridge include (1) north-directed thrusts where the sediment is gliding into deeper areas (as in the southern Rhodes Basin (Woodside *et al.*, 2000a) and elsewhere along the inner deformation front), (2) shear faults and flower structures along the outer margin of the eastern branch of the Mediterranean Ridge where differential movement of sediments is observed in a northeast-southwest direction, and (3) shearing and extension within the central, most-compressed part of the Mediterranean Ridge which provides pathways for fluid escape and mud volcanism from overpressured reservoirs below. Sometimes these structures are mistaken for – although they may be a response to – deep-seated tectonics.

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Figure 1. This is a schematic view of the eastern Mediterranean region showing places and features mentioned in the text.

Figure 2. Fault scarp (oriented NE-SW) cutting across the Anaximander Mountains. The rocks are of Bey Dagları affinity; they are similar to those onshore in Turkey. Gas seeps through fractures along the scarp are indicated by the presence of clusters of vestimentiferan worms. This is a photograph at a depth of about 1800 m from the submersible *Nautilie* during the MEDINAUT expedition in December 1998.

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