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The Pliocene–Quaternary tectonic evolution of the Cilicia and Adana basins, eastern Mediterranean: Special reference to the development of the Kozan Fault zone

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ABSTRACT

A grid of high-resolution multi-channel seismic reflection profiles allows the detailed mapping of the Kozan Fault zone in the Cilicia and Adana basins. The zone is delineated by an arcuate zone consisting of several ENE–WSW and NNE–SSW striking, closely-spaced high-angle extensional faults which define an ~300 km long and 15–20 km-wide "lazy-S" shaped structure along the southeastern fringes of the Taurus Mountain and along the northwestern margins of the Cilicia and Adana basins. In the Cilicia Basin the zone consists of several high-angle faults which exhibit small dip separations on the M-reflector and have tip points situated mainly in the lower and middle portion of the Pliocene–Quaternary succession. In the Adana Basin a family of northeast-striking and southeast dipping extensional faults occurs along the western and northwestern margin of the basin. The faults cut down with relatively steep dip into the ~700 ms thick Tortonian and older Miocene successions.

Multi-channel seismic reflection profiles show that three prominent seismic markers divide the uppermost Messinian–Recent successions in the Cilicia and Adana basins into three subunits: the uppermost Messinian–Lower Pliocene subunit 1C between the M- and A-reflectors, the Upper Pliocene subunit 1B between the A- and P-reflectors and the Quaternary subunit 1A between the P-reflector and the seafloor. Prominent delta lobes are identified in the seismic profiles that are correlated with the ancestral Göksu River. Isopach maps constructed using depth-converted seismic reflection profiles show clear temporal and spatial variations of the delta lobes of the Göksu River during the latest Messinian–Recent. The uppermost Messinian–Lower Pliocene delta lobe is situated furthest to the northeast whereas the youngest Quaternary lobe is situated furthest to the southwest, with 20–35 km displacement along a northeast–southwest line, which suggests a conservative estimate of 0.43–0.75 cm/yr sinistral slip for the Kozan Fault zone.

1. Introduction

The Cilicia–Adana basin complex is an arcuate and elongate depocenter nestled between the Misis–Kyrenia Lineament in the south and southeast and the Taurus Mountains of southern Turkey in the north and northwest (Figs. 1, 2). The Cilicia Basin is naturally divided into an E–W-trending deeper Outer Cilicia Basin in the west and a NE–SW-trending shallower Inner Cilicia Basin in the northeast (Fig. 2). The Adana Basin even farther to the northeast represents the onshore extension of the marine Cilicia Basin, and is similarly bounded on its southeastern margin by the Misis–Kyrenia Lineament. Four rivers (Seyhan, Ceyhan, Tarsus and Göksu) provide most of the siliciclastic input into the Cilicia–Adana basin complex: the Seyhan, Ceyhan and Tarsus rivers form a major deltaic complex that occupies the Adana Basin (Fig. 2).

The morphology of the seafloor in the Cilicia Basin is primarily controlled by the sediment input from large rivers that flow into the region (Fig. 2). The continental shelf is generally <5 km wide, but widens considerably to >45 km southwest of the Adana Basin, where the shelf is underlain by large delta complex (Fig. 2). A NE–SW-trending relatively shallow zone can be traced from the northeastern tip of Cyprus toward the Misis Mountains of southern Turkey, physiographically dividing the Cilicia Basin in the northwest from the Latakia Basin in the southeast. The water depth gradually increases

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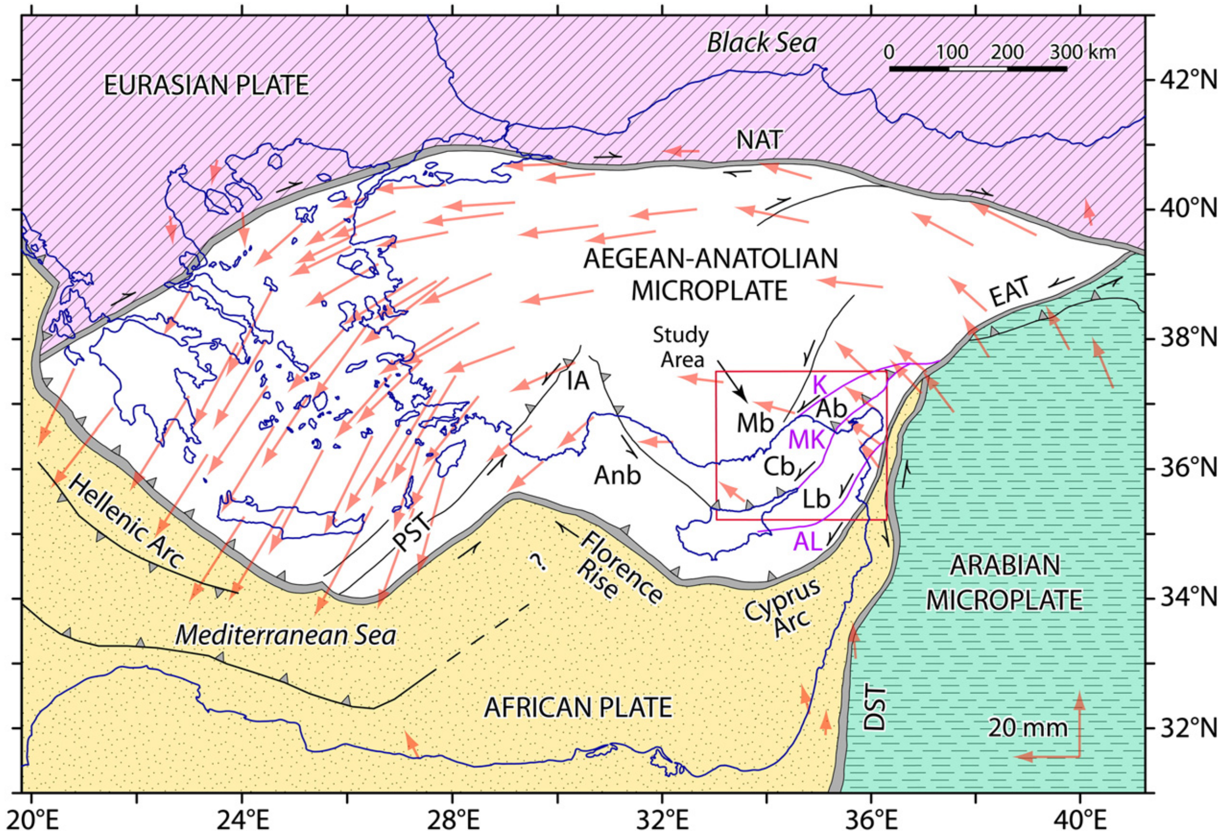

Fig. 1. Simplified tectonic map of the eastern Mediterranean, compiled from Şengör and Yılmaz (1981), Hancock and Barka (1980) and Dewey et al. (1986). Red box shows the study area. Ab = Adana Basin, AL = Amanos–Larnaka Fault zone, Anb = Antalya Basin, Cb = Cilicia Basin, DST = Dead Sea Transform Fault, EAT = East Anatolian Transform Fault, IA = Isparta Angle, K = Kozan Fault zone, Lb = Latakia Basin, MK = Misis–Kyrenia Fault zone, NAT = North Anatolian Transform Fault, PST = Pliny–Strabo Trenches. Red arrows indicate the sense of plate motion relative to a fixed Eurasian plate (McClusky et al., 2000); half black arrows indicate transform/strike–slip faults.

from the Inner to the Outer Cilicia Basin, reaching >1000 m in the central Outer Cilicia Basin. Farther to the west the water depth sharply increases to >2500 m into the Antalya Basin.

The structural framework of the Neogene basins in the northeastern Mediterranean region is primarily controlled by several arcuate NE–SW-trending major fault zones: the Kozan, Amanos-Larnaka and Misis–Kyrenia faults (Fig. 1). These fault zones are splays of the larger, sinistral East Anatolian Transform Fault which has been active since the mid-Tertiary (Fig. 1; Şengör et al., 1985). The Ecemiş Fault zone, a splay of the North Anatolian Fault, also played a role in the evolution of smaller basins in eastern Mediterranean. The scientific objectives of this paper are: (i) to describe the structural and stratigraphic architecture of the Pliocene–Quaternary successions in the Cilicia and Adana basins, (ii) to evaluate the temporal and spatial variations of the Pliocene–Quaternary sedimentary fill associated with the deposition from the Göksu River and so (iii) to determine the nature of the displacements associated with the Kozan Fault zone during the Pliocene–Quaternary.

2. Data acquisition

The principal data used in this paper consist of (a) ~5000 km of multi-channel seismic reflection profiles collected in 1991, 1992 and 2008, using the Memorial University of Newfoundland (MUN) equipment on RV *Koca Piri Reis* of the Institute of Marine Sciences and Technology (IMST) and the Seismic Laboratory (SeisLab) facilities of IMST, Dokuz Eylül University, (b) ~2000 km of multi-channel seismic reflection profiles provided by the Turkish Petroleum Corporation, (c) ~1500 km of single-channel seismic reflection profiles collected in 1988 and 1990 using the RV *Koca Piri Reis*, and (d) biostratigraphic and lithostratigraphic data from several onshore and offshore exploration wells, provided by the Turkish Petroleum Corporation (Fig. 3). The acoustic source for the MUN multi-channel data consisted of a Halliburton sleeve gun array, employing gun sizes of 40, 20 and 10 in.^{3} (656, 328 and 164 cm^3), with the total volume varying during maintenance cycling of the guns, but typically 200 in.^{3} (3277 cm^3) in 1991 and 2008 and 90–120 in.^{3} (1475–1968 cm^3) in 1992. Shots were fired every 25 m, and reflections were detected by the full 48 channels in 1991, the nearest 12 channels of a 48 × 12.5 m multi-channel streamer in 1992 and by a 96 × 6.25 m multi-channel streamer in 2008. The resultant 12-fold (1991 and 2008) and 3-fold (1992) data were recorded digitally for three seconds (with delay dependent on water depth) at a 1 ms sample rate, using a Texas Instruments DFS V instrument in 1991 and 1992 and a Hydroscience Technology NTRS2 seismograph in 2008. The multichannel data were processed at MUN, with automatic gain control, short-gap deconvolution, velocity analysis, normal moveout correction, stack, filter (typically 50–200 Hz bandpass), Kirchhoff time migration, and adjacent trace sum. Despite the relatively low source volume and low fold, reflections are imaged to 3 s two-way time (twt) below the seabed.

The velocity in the Pliocene–Quaternary sediments increases from ~1500 m s^{-1} at the sediment–water interface to ~2100–2300 m s^{-1} at the base of this succession, immediately above the M-reflector (see below). The functions used to calculate interval velocities were derived from the velocity analysis stage of the seismic data processing, and guide time-to-depth conversion of the seismic reflection profiles. Sites for velocity analysis have well-defined semblance bulls-eyes and were selected where reflectors are nearly horizontal to ensure that no velocity anomalies resulting from dipping reflectors are included in the analysis. Because the relationships involving two-way times and interval velocities vary slightly across the basin, velocity profiles were chosen