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Dating and correlation of the Quaternary fluvial terraces in Syria, applied to tectonic deformation in the region

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ABSTRACT

New data on location, height, and composition of terraces of the El-Kabir and Orontes rivers in Syria are represented. By combined use of paleontological, archaeological, paleomagnetic, and radio-isotopic methods, ages of these river terraces are estimated and they are correlated with the Euphrates River terraces. The age of the terraces is defined more precisely by evidence of synchronism of the El-Kabir alluvial terraces and the marine terraces of the Mediterranean coast. The average rates of incision during different time intervals were estimated in the studied valleys and their segments using relative height of the terraces. This gives the possibility of approximately estimating a rate of the Quaternary uplift in different tectonic provinces of Syria as well as rates of vertical movements on the Lattaqieh (the El-Kabir valley), Hama (the Orontes valley), and Euphrates (the Euphrates valley) faults. The rates of incision were usually small in the earlier stages of the valley formation and increased later. The Middle and Late Pleistocene rates of the valley incision reach ~220–280 mm/ky in the El-Kabir valley (the Coastal Range-anticline), ~80–130 mm/ky in the Orontes valley and the Euphrates upstream of the Assad Reservoir (the mobile platformal Aleppo Block), and ~25–30 mm/ky in the Euphrates valley downstream of the Assad Reservoir (southwestern side of the Mesopotamian Foredeep).

1. Introduction

The aim of the paper is to estimate the Quaternary relative vertical movements in different tectonic provinces of Syria by using characteristics of the Quaternary terraces of large rivers. Because this estimation rests on the correctness of chronological correlation of the river terraces, the main attention is given to defining the ages of the terraces by a combination of dating methods, including geological and geomorphological studies, radio-isotopic dating, archaeology, paleontology (molluscs, mammals, and palynology), and magneto-stratigraphy. We studied three large rivers of the region: El-Kabir, Orontes, and Euphrates.

In this paper, we use the new stratigraphic division of the Pliocene and Quaternary, confirmed in the 33rd IGC (www.stratigraphy.org). We use the following abbreviations to describe the river valleys: N_1 – Miocene, N_1^3 – Late Miocene, N_2 – Pliocene, N_2^1 – Early Pliocene (Zanclean), N_2^2 – Late Pliocene (Piacenzian), Q_1^1 – Gelasian, Q_1^2 – Calabrian, Q_2 – Middle Pleistocene, Q_2^1 – early Middle Pleistocene, Q_2^2 – late Middle Pleistocene, Q_3 – Late Pleistocene, Q_3^1 – early Late Pleistocene, Q_3^2 – late Late Pleistocene, Q_4 – Holocene, H – altitude of terrace a.s.l., h – elevation above the river water level, M – total thickness of gravel, M′ – thickness of alluvium observed in outcrops, m – thickness of the upper fine-grained part of the alluvium, and s – site of observation.

2. Regional background

The region of study occupies the northwestern and northern Arabian Plate within Syria. The plate is bordered from the west by the Dead Sea Transform (DST). The recent pattern of the Syrian–Lebanese part of the DST originated at 3.4–4 Ma (Trifonov et al., 1991; Barazangi et al., 1993; Rukieh et al., 2005), or at ~3.7 Ma (Westaway et al., 2006). The East Anatolian fault zone (EAFZ) originated along the north-western margin of the plate at around the same time (Rukieh et al., 2005), or at the end of the Miocene (N_1^3) (Westaway, 2004). The northern part of the plate is the

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northwestern termination of the Mesopotamian Foredeep. Its northern part is deformed by the Marginal Folds of Turkey (Ilhan, 1974). These are bounded to the north by the Bitlis (Eastern Taurus) Thrust, corresponding to the Neo-Tethys suture (Robertson, 2000; Robertson et al., 2004). The fold-thrust Palmyride belt adjoins the termination of the Foredeep in the west. The DST, the EAFZ and the Palmyrides border the platformal Aleppo Block (Fig. 1). Its south-eastern boundary is marked by the Rasafeh–El-Faid fault zone that probably continues the reverse-sinistral Serghaya fault to the NE (Trifonov et al., 2012).

The Lebanon Range in the south and the Coastal Range in the north occupy the dominate part of Lebanon and northwest Syria. These ranges began to rise as marginal anticlines of the Arabian Plate in the Miocene when the northern DST follows Roum Fault and farther along the continental slope of the Mediterranean (Trifonov et al., 1991; Rukieh et al., 2005). The El-Kabir Basin with

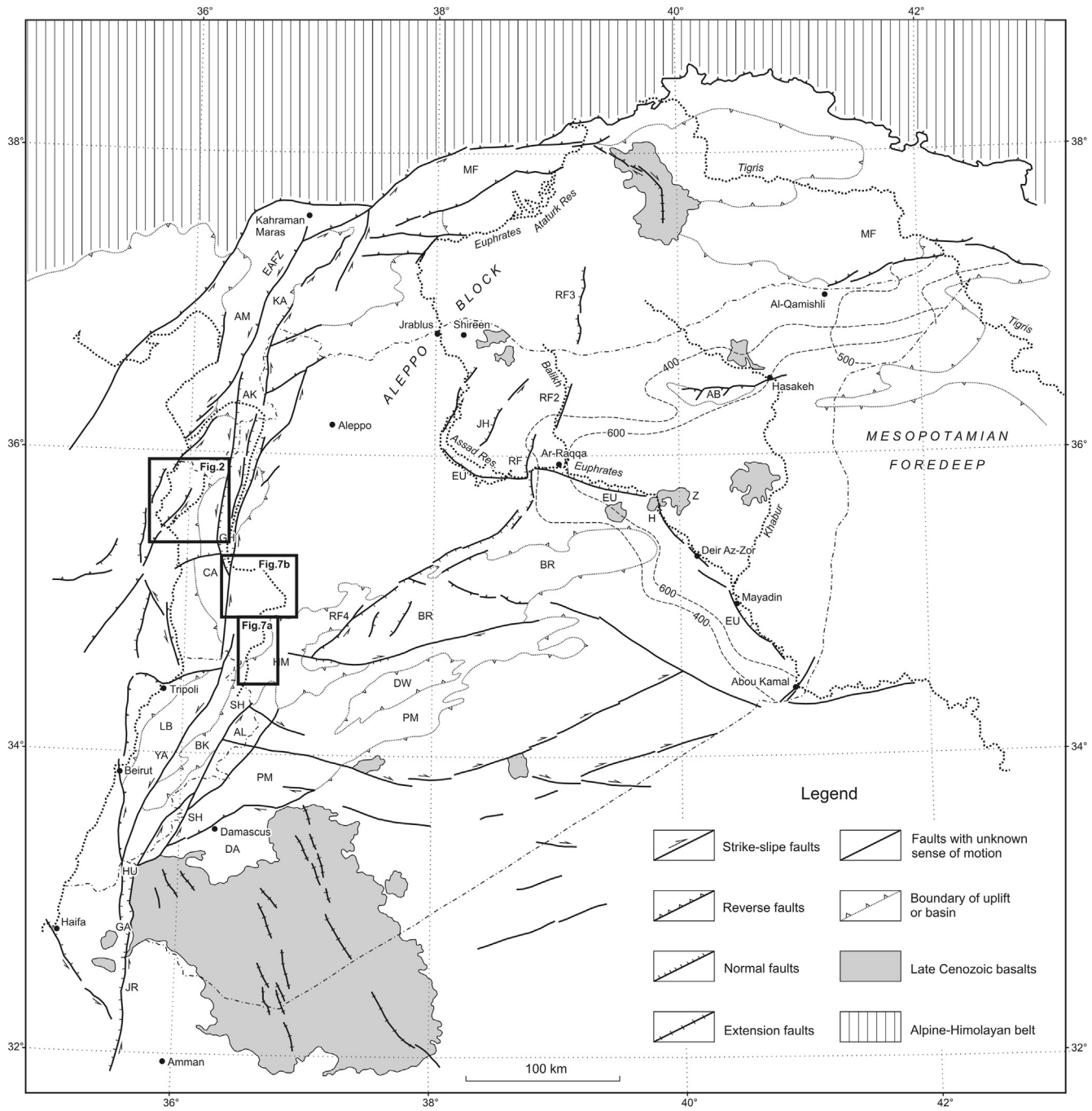

Fig. 1. Late Pliocene–Quaternary (the last ~3.5 Ma) tectonic features of the northern part of the Arabian plate. The 400-m and 600-m Miocene isopachs and the 500-m Pliocene isopach demonstrate the structure of the Mesopotamian Foredeep. Contours of Figs. 2 and 7 are shown (after Trifonov et al., 2012, with additions). *Uplifted anticline* zones: AB, Abdel Aziz; AL, Antilebanon; BR, Bishri, the Northern Palmyrides; CA, Coastal of Syria; LB, Lebanon; MF, Marginal Folds of Turkey; PM, Southern Palmyrides. *Faults and fault zones*: AM, Amanos, a segment of the EAFZ; EAFZ, East Anatolian; EU, Euphrates; JH, Beer Jabel–Heimer Kabir; JR, Jordanian, a segment of the DST; RF, Rasafeh–Faid and its continuation (RF2, RF3 and RF4); SH, Serghaya; YA, Yammuneh, a segment of the DST. *Basins*: AK, Amik; BK, Bekkaa syncline; DA, Damascus; DW, Ad Daw; GA, Galilee Sea pull-apart basin of the Dead Sea Transform (DST); GH, El Ghab pull-apart basin of the DST; HM, Homs; HU, Hula pull-apart basin of the DST; KA, Karasu graben. Basaltic fields: H, Halabiyeh; Z, Zalabiyeh.

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