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High-altitude Plio–Quaternary fluvial deposits and their implication on the tilt of a horst, western Anatolia, Turkey

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Abstract

This study investigates the origin and regional tectonic implications of high-altitude Plio (?)–Quaternary fluvial deposits developed over the Bozdağ horst which is an important structural element within the horst–graben system of western Anatolia, Turkey.

A total of 23 deposits occur near the modern drainage divide comprising fluvial to occasionally lacustrine deposits. The deposits are all elongated in N–S direction with a width / length ratio of 1 / 10. The largest of them is of 13 km in length with a maximum observable thickness of about 100–110 m. Morphological, lithological, deformational characteristics of these deposits and the drainage system of the area all suggest that the deposits were formed due to uplift and southward tilting of the Bozdağ horst. This tilting which is estimated as 1.2° to 2.2° caused accumulation of the stream load along channels flowing from south to north. All the deposits were later dissected by the same streams with the exception of one deposit which still preserves its original lake form. These deposits are of Quaternary age, which corresponds to the latest N–S directed extensional tectonic phase in the region.

Keywords: Fluvial deposits; Tilting; Drainage reversal; Bozdağ horst; Western Anatolia; GIS; Küçük Menderes

1. Introduction

Fluvial systems are one of the most important tracers of crustal deformation in tectonically active areas. Tectonic activity in most cases controls morphology of the valleys and determines the nature of the erosional and/or depositional processes that occur within these valleys. Quantitative measurements of these elements allow earth scientists to identify, measure and characterize the tectonic activity affecting a region (Keller and Pinter, 2002). Interactions between tectonic activity and fluvial processes have been well documented for different aspects of fluvial systems such as base-level changes (Harvey and Wells, 1987; Burbank et al., 1996; Bonnet et al., 1998; Humphrey

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and Konrad, 2000; Mather, 2000; Stokes and Mather, 2000), drainage reversal (Kafri and Heimann, 1994; Fisher and Souch, 1998; Ben-David et al., 2002, Ginat et al., 2002), tilt-block tectonics (Cox, 1994; Wende, 1995; Ginat et al., 1998; Synder et al., 2000; Cox et al., 2001; Hsieh and Knuepfer, 2001; Sun et al., 2001; Stokes and Mather, 2003) and general evaluations (Ouchi, 1985; Holbrook and Schumm, 1999).

In order to quantify these effects, many geomorphic or morphometric indices have been developed throughout the literature. Since landforms possess a fractal nature, the indices should be evaluated at two different scales: one regarding the general and regional situation and the other regarding a very local scale which is characterized by the attributes of a pixel in a Geographical Information System. Some of the pixel indices in which the measured attributes are limited to few meters to few hundred meters can be cited as: first derivatives (Slope, aspect, flow path length, profile curvature, plan curvature, etc.), and others as higher derivatives (topographical wetness indices, stream-power indices, radiation indices, temperature indices, etc). An excellent review of these indices can be found at Wilson and Gallant (2000). On the other hand the regional indices deal with much larger areas and reflect the effects of rapid tectonic deformation as recorded by the landform itself. Some of the indices as listed by Keller and Pinter (2002), used to characterize and to quantify tectonic activity are: hypsometric integral (Strahler, 1952), drainage basin asymmetry (Hare and Gardner, 1985; Cox, 1994), stream length-gradient index (Hack, 1973), mountain front sinuosity (Bull, 1977), ratio of valley floor width to valley height (Bull, 1977) and many researchers have explored the relations among these indexes (Silva et al., 2003). As the drainage system itself records the stages and patterns of development and long-term evolution of the landscape that exists (Gelabert et al., 2005) some simple measurements can enlighten the saga of landscape development. Among these measurements, drainage basin asymmetry is the one which can be applied to smaller areas and pin point the measurements to individual drainage valleys while the rest are applicable mainly to more regional approaches with larger systems.

A series of river channels and associated depressions are located over the Bozdağ horst (western Anatolia, Turkey) near the drainage divide between the Gediz graben to the north and Küçük Menderes graben to the south. The important issue about these channels is that twenty-three of these channels are filled with continental deposits, dominantly of fluvial origin. Although the presence of these deposits has been known for a long time, their evolution and relation to regional tectonics have not been characterized. Systematic occurrence and their elevation above base level suggest that these deposits are rare geological features formed under specific conditions.

In the light of the literature and the inherent recording nature of the drainage systems, the purpose of this study is to introduce the geometry, pattern and evolution of Plio (?)–Quaternary active drainage channels and their relevant deposits while interpreting their origin with respect to recent tectonic activity in western Anatolia. In order to reach this goal the analytical capabilities of Geographical Information Systems are utilized.

2. Regional geological setting

The Bozdağ horst is located within the E–W trending Neogene–Quaternary horst–graben system of western Anatolia between Gediz–Alaşehir graben (GAG) to the north and Küçük Menderes graben (KMG) to the south (Fig. 1). It is situated in a seismically active continental extensional terrain where extension has operated since the Early Miocene. In summary, the driving mechanism of neotectonic period in Anatolia and surrounding region resulted from the final closure of Neotethyan oceans due to the collision between promontories of the Eurasian and African plates and the migration of the Anatolian–Aegean Plate in between them onto the African Plate along the Mediterranean ridge. However, the neotectonic extensional history of western Anatolia discussed extensively and various evolutionary models for the system has been proposed. These extensional models based on the rifting process as a continuous rifting or as two stage rifting models are closely associated with the timing of rifting, the order and origin of the extensional processes. The models are; 1) the *tectonic escape model* proposes the rifting since Late Serravalian (12 Ma) (e.g. Dewey and Şengör, 1979), 2) the *roll-back model* ("Back arc spreading model") propose rifting to have occurred between 60 and 5 Ma