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Volcanic disruption and drainage diversion of the palaeo-Hudut River, a tributary of the Early Pleistocene Gediz River, Western Turkey

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ABSTRACT

The importance of extrinsic drivers of fluvial system behaviour (climate, tectonics, eustatic sea level) over Quaternary timescales is well documented. However, comparatively fewer studies have been reported concerning the significance of more localised changes at reach to sub-catchment scale, over these extended (10^4–10^6 years) timescales. In this paper we examine the Early Pleistocene sedimentary record of the palaeo-Hudut River and compare it with the record from the trunk river into which it drains, the Gediz River of Western Turkey. Both the Gediz River and the Hudut River were subjected to major localised disruption during the Early Pleistocene as a consequence of volcanism but their respective responses to these events appear to differ. Observations are reported from the sedimentary sequence buried beneath the lavas which cap the Burgaz plateau. These sediments record a remarkable amount of detail for a significant period of the Early Pleistocene. These suggest that the palaeo-Hudut system responded largely to the creation and failure of downstream lava dams, both through channel incision and subsequent filling, and via route diversions around lava dams and their associated lakes. In contrast, the Gediz terrace record appears to demonstrate a river which was able to accommodate these changes more readily and hence, continue to undergo sedimentation–incision cycles consistent with a climate forcing.

1. Introduction

Quaternary fluvial archives are playing an ever increasing role in our understanding of landscape forming events on the continents. Often, however, questions are legitimately asked concerning the importance of extrinsic drivers of fluvial system behaviour (climate, tectonics, eustatic sea level) relative to intrinsic dynamical responses to local factors e.g. the degree of slope-channel coupling. There has been a tendency within the geological community to assume that extrinsic factors always override intrinsic controls and thus govern the widespread behaviour of large fluvial systems. While there is considerable evidence to support the premise that, for example, the catchment-wide terracing of large fluvial systems is driven by a combination of tectonics and climate change (e.g. Bridgland et al., 2007), the response at a local scale and especially within tributary valleys, may not reflect this general conclusion. Although comparatively few studies have been reported from tributary systems over extended 'geological' timescales (10^4–10^6 years), shorter timescale studies (e.g. Rains and Welch, 1988; Coulthard et al., 2005; Erkens et al., 2009) have stressed the importance of recognising the often asynchronous and conflicting responses of trunk valley and tributary valleys to local events e.g. landslides, volcanic events. Significantly the localised effects of base-level changes resulting from river capture have been reported from SE Spain (e.g. Mather, 2000; Stokes et al., 2002; Maher et al., 2007) but in this paper we examine the Early Pleistocene sedimentary record of a palaeo-Hudut River and compare it with the record from the trunk river into which it drains, the Gediz River of Western Turkey. Both the Gediz River and the Hudut River were subjected to major localised disruption during the Early Pleistocene as a consequence of volcanism.

The Gediz River, one of the main rivers of Western Turkey, rises on Murat Dağı (~2400 m) and over its ~275 km course to the Aegean, crosses some of the most important tectonic structures of Western Turkey (Fig. 1). In its upper reaches the river crosses three important north–northeast to south–southwest orientated sedimentary basins which were in-filled during the Miocene (Seyitoğlu and Scott, 1994;

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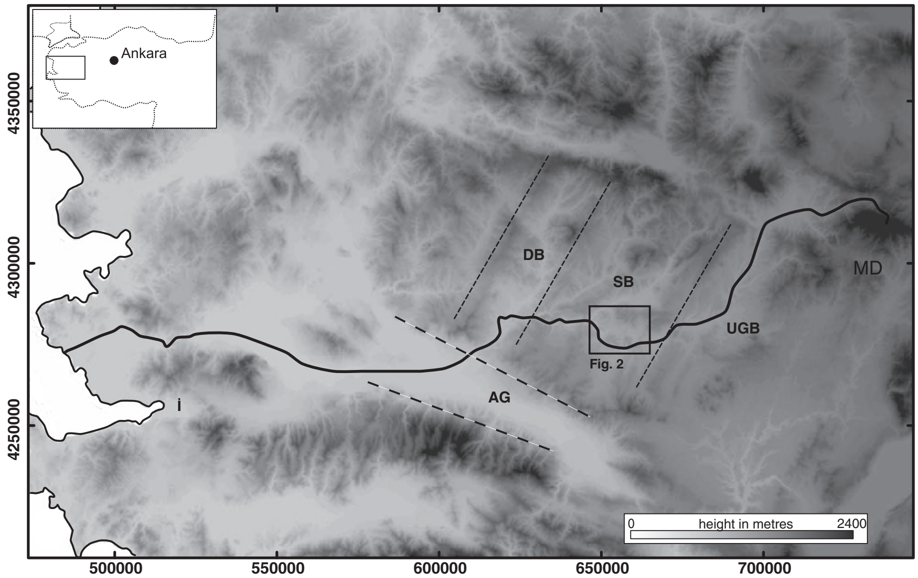

Fig. 1. General location: The Miocene sedimentary basins are demarcated and marked as: DB Demirci Basin; SB Selendi Basin; and UGB Uşak-Gūre Basin. The Plio-Pleistocene Alaşehir (Gediz) Graben is marked as AG. The city of İzmir is denoted by İ. Inset shows position of Fig. 1 in Turkey. All coordinates are from the UTM Zone 35 N origin. Background image is the ASTER GDEM (ASTER GDEM is a product of METI and NASA).

Seyitoğlu, 1997; Bozkurt, 2003; Purvis and Robertson, 2004; Purvis et al., 2005). Initially, after leaving the Murat Dağı, the Gediz flows southward down the axis of the Gūre Basin (the western sector of the larger Uşak-Gūre Basin [Fig. 1: UGB]), turns west, across a basement high in order to traverse the Selendi Basin (Fig. 1: SB) before crossing a further high basement ridge in order to enter the Demirci Basin (Fig. 1: DB), where the river has been dammed by the Demirkőprű Dam. Below the dam, the river emerges to the south and enters the active, East–west orientated, Aleşehir (Gediz) graben around Adala (Fig. 1: AG). Once in the graben, the river flows westwards, eventually entering into the Aegean Sea on the northern shore of the Gulf of İzmir (Fig. 1: İ).

The evolution of the modern Gediz drainage system postdates the infill of the internally, north–south, draining Miocene basins and largely reflects progressive incision in response to uplift and associated base-level changes related to the formation of the modern Alaşehir graben (Maddy et al., 2007). The timing of the onset of graben formation, the result of on-going regional crustal extension, is hotly debated (Koçyiğit et al., 1999; Yılmaz et al., 2000) but, it is generally agreed that the high angle faults which mark the latest phase of extension and bound the southern side of the present day graben, most likely originated within the past 5 Ma (Sarıca, 2000; Bozkurt, 2001; Bozkurt and Sözbilir, 2004). To the north of the graben, where the Gediz emerges, it is bound by a series of less dramatic, antithetic faults. Uplift of this northern flank of the graben has contributed to the uplift of the Miocene basins (Richardson-Bunbury, 1996; Bunbury et al., 2001) to the north, but it is more likely that a significant component of regional uplift is driven by an isostatic response to erosion (Westaway et al., 2004; Westaway, 2006). Whatever the precise cause of the uplift, uplift of the Miocene basins during the Quaternary is unequivocal.

The crustal extension associated with graben formation results in crustal thinning leading to the generation of volumetrically small amounts of rift shoulder, basaltic, volcanism. This volcanism generates over 80 small volcanic necks/cinder cones within the Selendi and Demirci Basins where, at least three generations of lava flows (the β2, β3 and β4 of Erinç, 1970) have been identified. The oldest necks and associated lava flows (β2) lie furthest away from the graben, with the most recent generation of necks/flows, closest to the northern boundary. Significantly the Kula volcanic field generates lavas which ultimately flow into the Gediz river (Ozaner, 1992), capping its deposits and preserving a fluvial archive of past environmental change (Westaway et al., 2003).

Maddy et al. (2005, 2007, 2008, 2012) describe extensive preservation of an Early Pleistocene river terrace staircase beneath the oldest lavas (β2) capping the Burgaz, Sarnıç and İbrahimağa plateau north of Kula (Figs. 2, 3). At least 11 terraces, thought to have formed in response to obliquity-driven (~40 ka) sedimentation–incision cycles, are identified and ascribed to the Early Pleistocene on the basis of the radiometric dating of the overlying basalts. Preserved alongside the Gediz deposits are the sediments laid down in a series of northerly derived tributaries emanating from the limestone uplands. Initially these sediments were ascribed to deposition on a series of interlocking alluvial fans (Maddy et al., 2008), but more detailed investigation described below, has resulted in the need for a revised model for their development.

2. Regional setting and field area geology

Our ongoing study of the Gediz River has examined in detail the exposed sedimentary records along a ~20 km reach of the current Gediz valley, within the Selendi basin, where there is extensive preservation of a Quaternary archive from beneath lava-capped plateau (Fig. 2). The Quaternary sediments and lavas lie upon the heavily eroded Miocene basin infill. The Selendi basin infill, which overlies predominantly metamorphic Basement rocks (typically schist, gneiss, marble and quartzite), comprises basal alluvial fan and high energy fluvial facies (Hacıbıkir Group). These are overlain by the fluvial facies of the Ahmetler Formation, which together with the overlying continental carbonate deposits of the Ulubey Formation, make up the İnay Group (Ercan et al., 1983). These sediments are accompanied, towards the centre of the Selendi Basin (north of the study area), by thick volcaniclastic detritus, dated to the Mid-Miocene, emanating from a basin-central stratovolcano (Seyitoğlu, 1997).

The progressive incision of the Selendi basin infill by the Gediz River and its tributaries, has led to the creation of a terrain with over 400 m of relative relief within the study area (Fig. 2). The Ulubey Formation (up to 300 m thick in the field area) was incised by the river leading to the creation of high plateau formed in limestone. Once incised down onto the Ahmetler Formation, the Gediz was able to create and preserve floodplains as a terrace staircase during continued episodic incision. Although the river subsequently cut