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Holocene flooding and river development in a Mediterranean steepland catchment: The Anapodaris Gorge, south central Crete, Greece

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ABSTRACT

Many Mediterranean steepland rivers are flanked by extensive alluvial and colluvial deposits, but Late Quaternary histories of channel and hillslope behaviour remain poorly constrained, primarily because of the limited availability of material suitable for dating. Study of a 4.8 km long reach of the Anapodaris Gorge, located in the lower part of an ~500 km^2 catchment in south central Crete, reveals a succession of well preserved, coarse-grained (predominantly cobble to boulder) and fine-grained (predominantly silt to sand) alluvial deposits that locally interfinger with, or are overlain by, coarse colluvial and tributary stream deposits. Detailed ground surveys, geomorphological mapping, sedimentological investigations, and geochronology (optically stimulated luminescence, radiocarbon, and lichenometry) have allowed detailed reconstruction of the timing and pattern of sedimentation and erosion over the mid to late Holocene. Widespread, coarse-grained aggradational episodes at c. 4.86–4.20 and c. 3.40–3.00 ka have been punctuated by incisional episodes and coarse sediment export, resulting in a suite of alluvial terraces. Comparison with other proxy Mediterranean environmental change records, particularly high-resolution marine and lake records, suggests that these aggradational/incisional episodes were primarily climatically driven, reflecting changes in the balance between hillslope/tributary sediment supply and high-energy flood events. By contrast, phases of widespread fine-grained aggradation at c. 1.90 ka, 1.13 to 1.10 ka, 0.85 to 0.70 ka and 0.21 ka provide evidence for decreases in flood competence, possibly coupled with up-catchment historical land use changes. Since the middle of the nineteenth century, several large floods have formed localised boulder berms and splays and have contributed to stripping of the fine-grained deposits from many parts of the gorge. The findings from the Anapodaris Gorge demonstrate the sensitivity of Mediterranean steepland catchments to rapid and/or short-lived Holocene climate change but also highlight the need for higher resolution data on historical and prehistoric land use changes.

1. Introduction

Steepland river systems are characteristic of the hilly and mountainous terrain of the Mediterranean region of southern Europe, the Levant and North Africa (Macklin et al., 1995). These rivers typically have boulder- or cobble-bed channels, but in more tectonically active regions, have commonly incised through Quaternary alluvial and colluvial valley deposits and into bedrock. At present, many are ephemeral or seasonal rivers but they can transport large sediment loads during infrequent high magnitude floods (e.g. Reid, 2002; Greenbaum and Bergman, 2006). Effective slope-channel coupling makes these rivers potentially responsive to short- and longer term environmental changes arising from tectonic, climatic, and anthropogenic causes that can increase runoff and sediment supply. Yet despite their geomorphological and hydrological importance in the Mediterranean, the historical and longer term Holocene development of these steepland river systems has been little researched outside of Corsica (Hewitt, 2002), the Pindus Mountains of northwest Greece (Hamlin, 2000), and Crete (Maas, 1998; Maas et al., 1998; Maas and Macklin, 2002). In large part, this is due to the limited availability of material suitable for dating, but there has also been the widespread misconception (e.g. Van Andel et al., 1990; Hooke, 2006) that all fluvial material of historical age in these steepland environments is related solely to human activity associated with soil erosion and accelerated gully development. While this may be partly true for some catchments underlain by highly erodible lithologies typical of recently uplifted Tertiary basins (Harvey, 1982), research in southwest Crete, for example, has shown that steepland rivers are characterised by a wider range of historical, Holocene and Pleistocene alluvial fill types, including

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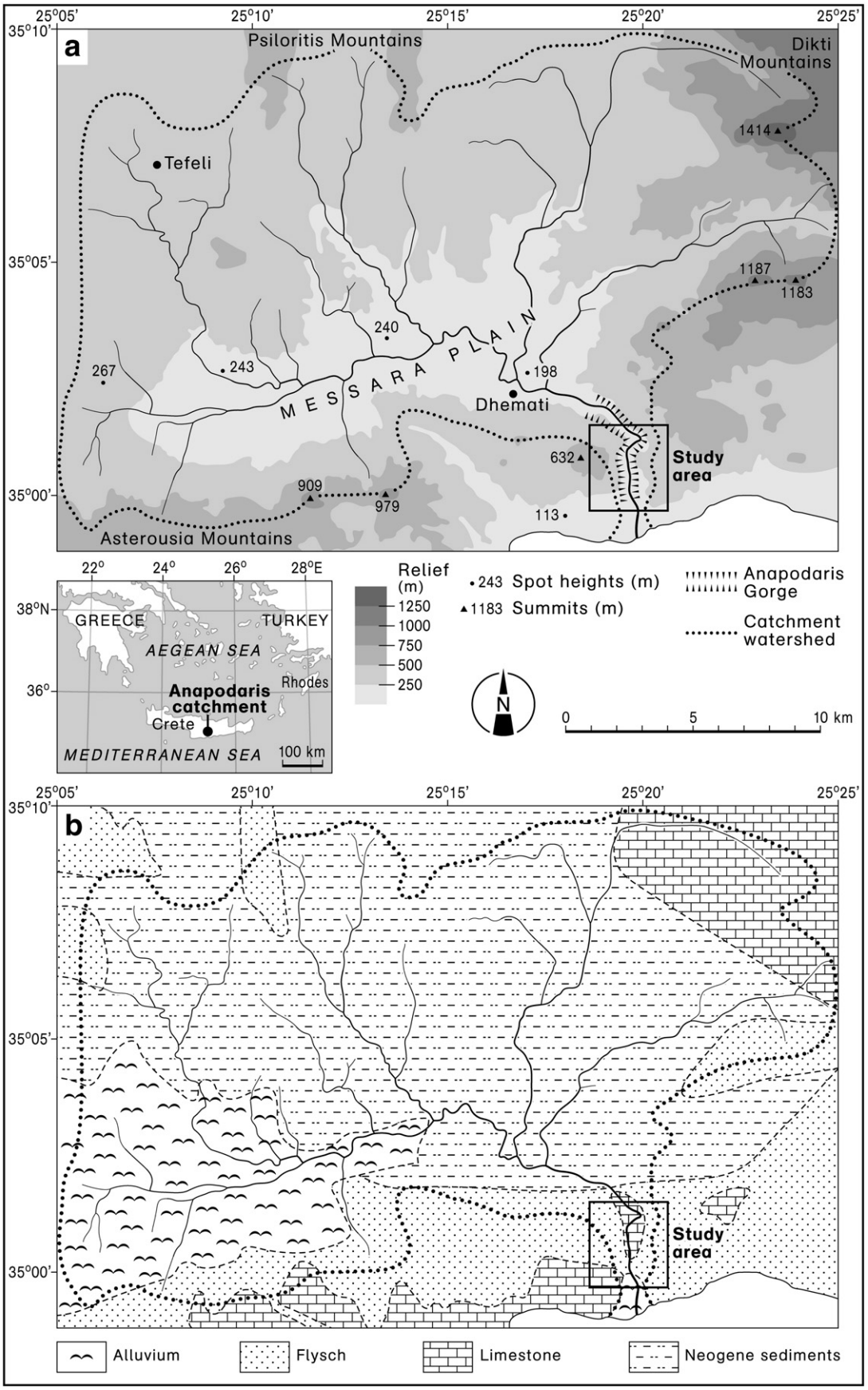

Fig. 1. (a) Location and topography of the Anapodaris catchment, south central Crete (spot heights and contours in metres above sea level), showing the location of the study area in the gorge; (b) geology of the Anapodaris catchment (compiled from various sources, including Rackham and Moody, 1996; ten Veen and Postma, 1999; Fassoulas, 2000).